

April/May 1987

# AIR & SPACE

Smithsonian

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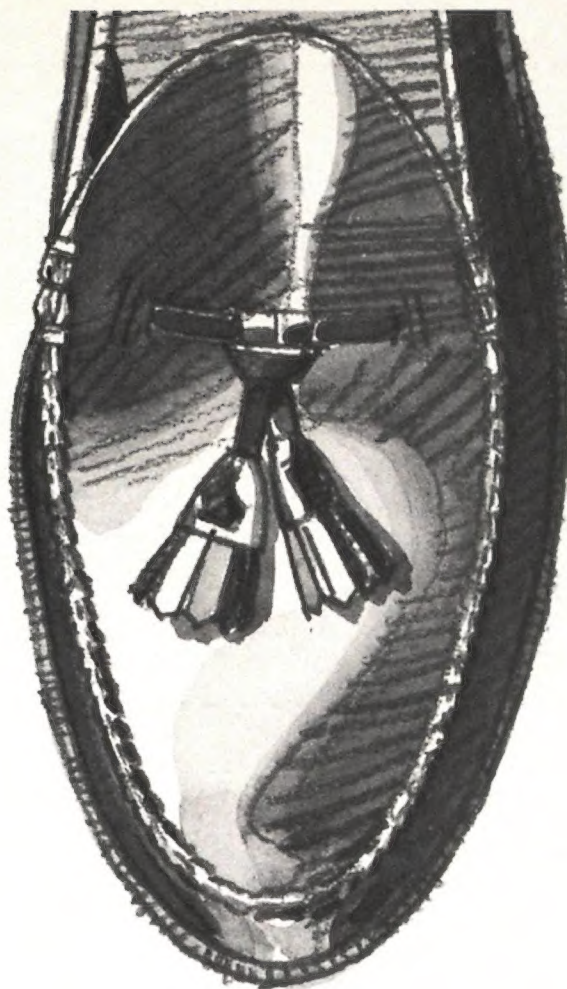
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Finally, since Jim can't make house calls, because we offer our shoes by catalog, we have to make sure they fit. To this end, we do extensive fit-testing in Dodgeville before offering any shoe to you. And make sure that, whatever style you order, a size 9 is a size 9, and a medium is a medium. This is by no means always true elsewhere.

When you order, Jim advises, order the size you now wear. Usually this will assure you a comparable fit in our Lands' End shoes. Should it not, send them back, and we'll adjust till we get it right. Then, from there on, you'll know for sure what you require.

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# AIR & SPACE

Smithsonian

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### 32 Fire Bombers



by Michael Tennesen  
photographs by Christopher Springmann

*In California and most of the West, where there's smoke, there's an airplane. Firefighting air tankers have proven remarkably effective at stamping out small blazes before they become big ones.*

### 42 Eyes on the Sky

by James E. Oberg

*Take a good-size beehive. Now give each bee a number, stir 'em up, and keep a log of all their movements. Got it straight? Now you're ready to go to work tracking objects in Earth orbit.*



### 54 Essay: Trial by Flying

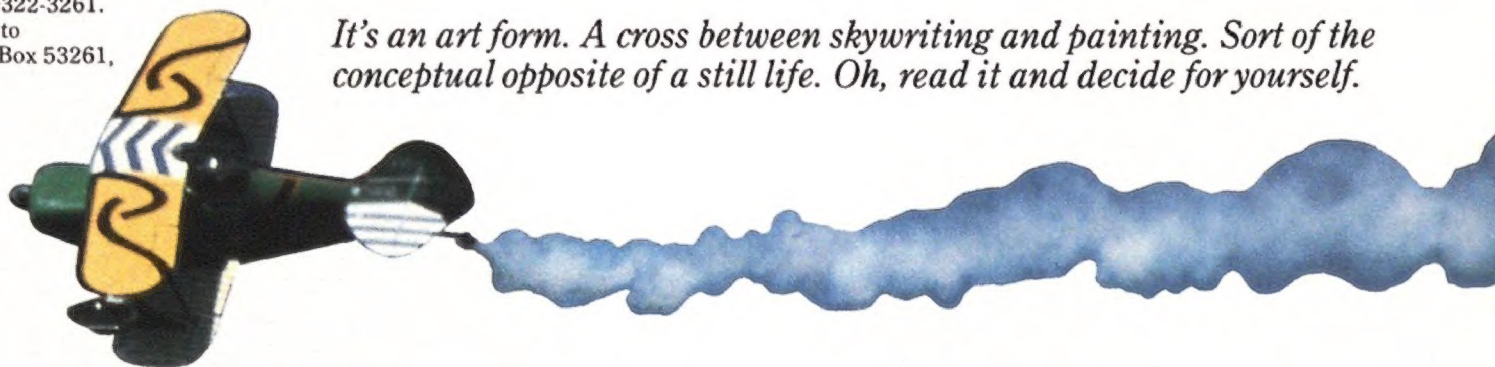
by F. Lee Bailey

*An attorney who has looked at the aftermath of aircraft accidents from both sides of the courtroom recommends some ways to revise an overburdened and wasteful compensation system.*

### 56 Smokin' Steve Poleskie

by Stephan Wilkinson

*It's an art form. A cross between skywriting and painting. Sort of the conceptual opposite of a still life. Oh, read it and decide for yourself.*



---

## 62 Dash 80

by R. G. Thompson

*Most airplanes spend their service lives pampered and polished. But Boeing's prototype for the 707 airliner was battered and dinged, sawed and hammered, and festooned with more ugly gear than a defensive tackle. But in the memories of the pilots who flew it, it positively shines.*

## 71 Something Old, Something New, Something Borrowed, Something Blew — by R. G. Thompson

74



## The Big Picture

by Steven L. Thompson  
illustrations by Dale Glasgow

*They used to call it "flying blind." With this new Air Force technology, you won't have to look outside a cockpit to see where you are. You'll just wear the world on your head.*

## 84 The Curator of Cosmic Dust

by Alcestis Oberg

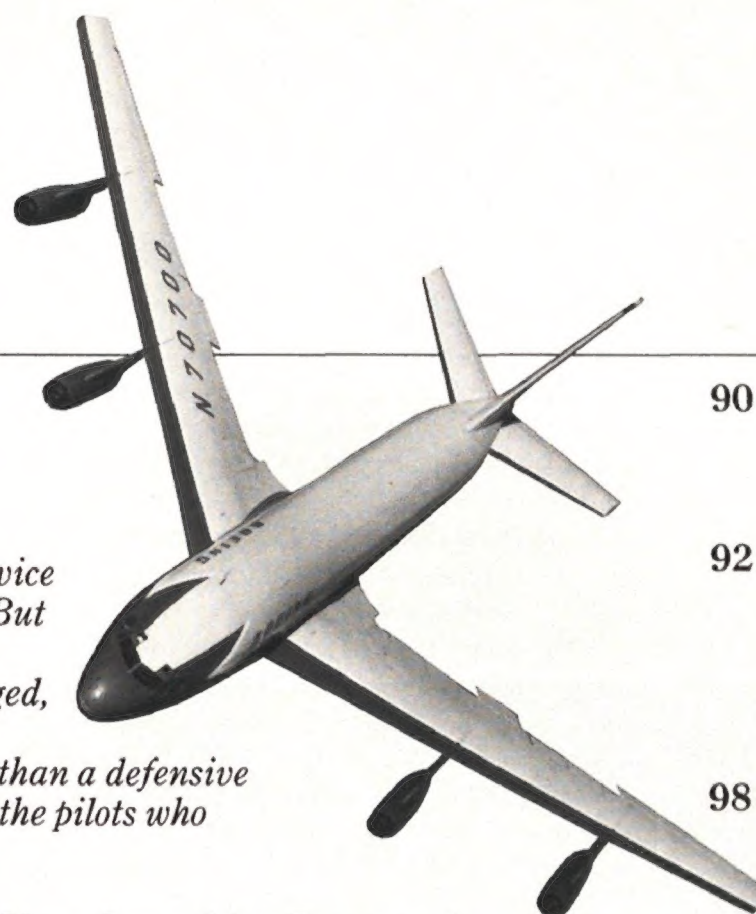
*Michael Zolensky has been collecting particles that drift down to the surface of the Earth from somewhere out there in space. Judging from the miniscule size of his collection, the cosmos could pass a white-glove inspection.*

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### Special Insert: The Satellite Sky

by Saunders Kramer

*Included with this issue is a foldout poster depicting the constellation of spacecraft in orbit around planet Earth, including every serviceable artificial satellite for which data have been published and for which a function is either known or has been surmised. Periodic updates will be provided in Air & Space/Smithsonian so that readers may add newly launched satellites and delete those spacecraft that are out of service.*



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## 90 Groundling's Notebook *The Happy Landing* by Elaine de Man

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Cover: Terry Eiler combined images to produce this composite photograph of the Air Force's experimental cockpit display.

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## A Revolution in Resolution

In Washington, a resolution is usually thought of as a measure expressing the will of Congress. But recently the government has developed an interest in another type of resolution—how well we can see Earth from space.

The United States launched its first Landsat remote sensing satellite in 1972, and by 1985 a total of five satellites had been launched and the system worked so well that the government turned it over to the private sector. Over Landsat's lifetime, remote sensing technology has become increasingly sophisticated; satellites are now generating mountains of raw data, while methods for converting it to useful information barely keep pace. It remains to be seen whether Landsat's new operator, Eosat, will be able to convert the Landsat operation into a profitable business venture. But meanwhile, many scientific disciplines have come to depend on the increasing resolution of images collected by Landsat satellites.

A satellite's ability to distinguish detail depends upon the resolution of its sensors and images. Electronically generated images are made up of small picture units called pixels, and the smaller the piece of ground a pixel covers, the better the resolution. The first Landsat satellite provided a resolution of 80 meters per pixel; current Landsats can resolve to 30 meters. A typical Landsat image is made up of millions of pixels. The thematic mapper instrument aboard Landsats 4 and 5 produces high-resolution black-and-white images that measure 6,000 pixels wide by 6,000 pixels long—a total of 36 million little boxes.

And that's not all Landsat does. The system offers spectral resolution, which distinguishes among different materials on Earth's surface. Landsat sensors record images in different spectral bands, like the bands of color a prism produces as it breaks up light. The choice of colors to be recorded depends on what's being studied—it could be anything from the extent of mountain snow cover to variations in the color of sand dunes. Landsat's thematic mapper can record images in

seven spectral bands, and a combination image that includes data collected in all seven bands would produce a digital picture 6,000 by 6,000 pixels multiplied by seven, or 252 million pieces of information about an area that measures 180 kilometers, or about 111 miles, on a side.

While scientists and their computers contend with the size and complexity of these images, sensor systems with even higher resolution are in the works. For example, because different minerals reflect light in different wavelengths, an airborne instrument with 128 spectral channels is proving valuable in defining mineral deposits worth mining. The French SPOT satellite produces images that cover a smaller area than Landsat's but provide better spatial resolution: 10 meters per pixel. SPOT's higher-resolution imagery allows scientists to obtain more accurate estimates of agricultural production and detailed mapping of changes on the surface of the Earth over time (another dimension in resolution).

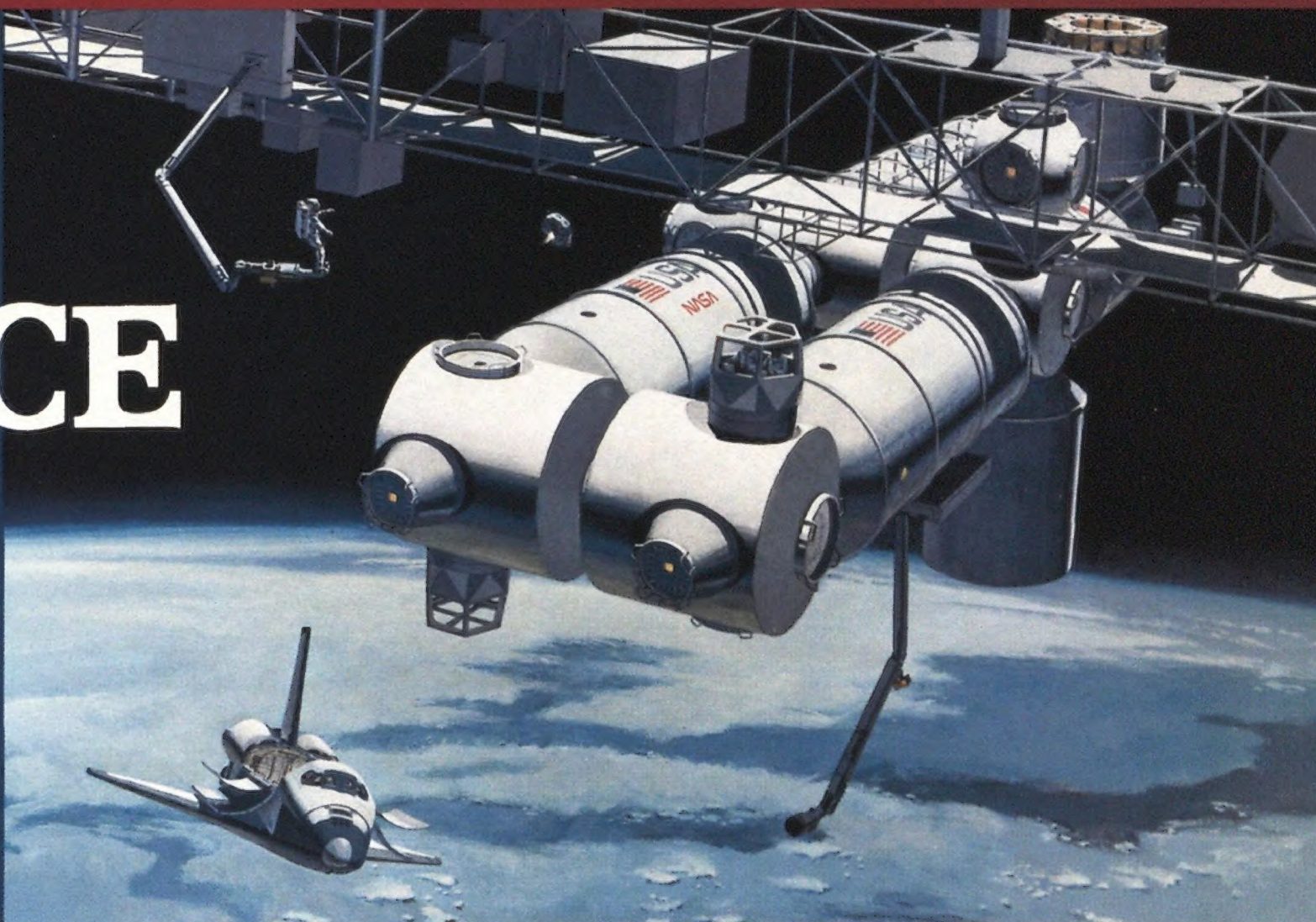
High-resolution images and a 15-year record of satellite observations are providing a space age view of how Earth is changing. Images from land and ocean remote sensing satellites and from meteorological satellites—even pictures taken from the space shuttle—are revealing how weather patterns develop, how Earth's climate is evolving, how human activity is changing the environment.

But how can the National Air and Space Museum show this to visitors? The high-tech beauty of an intricate space sensor can't compare with the grace and mystique of a sleek and spooky U-2 surveillance aircraft—but curators were able to use both in assembling the Museum's newest exhibit, "Looking at Earth." The exhibit shows how airborne and spaceborne images are used to study our planet. Check it out on your next trip to the Museum, keeping in mind how improvements in resolution over the past 15 years have sharpened our view of Earth.

—Ted A. Maxwell is the Chairman of the Center for Earth and Planetary Studies at NASM.

# SPACE

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final  
frontier



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## Letters

### Azores Revisited

I was surprised and delighted to read "Christmas in the Azores" by George Long in the December 1986/January 1987 issue. I was chief mechanic at Pan Am's Horta station from June 1939 to July 1940 and lived through that episode along with George and approximately 10 other American PAA staff members.

It was one of the more hectic times in my tour of duty. When things were going well, duty in Horta was on the humdrum side. However, each trip we handled had its own potential for challenge and the unusual. My 13-month stay there was a worthwhile experience.

I would like to see additional items of this type in your magazine. These unpublished incidents are as much a part of aviation history as the headline stories, and often illustrate the kind of effort it took to make the headlines possible.

*John D. Maas*  
Los Angeles, California

### That's The Spirit

Hearty congratulations to *Air & Space/Smithsonian* for the magnificent cover story on Alan Bean and his post-astronaut career ("To Make the Moon More Beautiful," February/March 1987).

Alan Bean's wonderful paintings vividly rekindle visions of mankind's space efforts and accomplishments. The personal excitement of space travel and exploration that his paintings stirred within me helped to shake the post-*Challenger* lethargy. I hope the article reawakened the spirit of space travel in others as well.

*Robert A. Fromtling*  
Westfield, New Jersey

### Country Flying

Thanks for the article "Home Is Where the Hangar Is" (Flights & Fancy, December 1986/January 1987). It pleases me to find stories about us small plane flyers and the

little airports we fly from. Many astronauts, fighter pilots, and airline pilots had their boyhood dreams kindled by small planes and actually learned to fly in Cessnas. A part of the joy of aviation comes from country flying and must be preserved.

*John W. Paynter*  
New Canaan, Connecticut

### Ham-fisted

The article in the December 1986/January 1987 issue entitled "Homemade Satellites" by Nancy Shute was very refreshing.

To read in a general circulation magazine something about the contributions amateur radio operators have made to science and technology is rare. Perhaps I can assist in explaining how amateur radio operators became known as hams.

Until Marconi invented radio, the only people who used or knew Morse code were professional telegraph operators. These were the people who worked for Western Union, the railroads, and the newspaper wire services. They prided themselves on the smoothness of their fists. When the amateurs began experimenting with radiotelegraphy, the professionals scorned the "ham-fisted operator" or "lid." Amateur radio operators, in a sense of perversity, made the pejorative term "ham" their very own. "Lid" is still used by amateur radio operators in the pejorative sense.

Best wishes, or as hams phrase it, 73.  
*James E. Sackey*  
N9ESM  
Great Lakes, Illinois

### Window Seat

I enjoyed K.C. Cole's "I Do Windows" (Groundling's Notebook, December 1986/January 1987). I always try to get a window seat and have seen many interesting things from the air. Being stuck over the wing in a large jet is a bummer. I see somebody else prefers the view to in-flight movies.

I have always wondered why airlines



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can't keep their windows clear. Many are so scratched you can't see a thing for scattered light if you're on the sunny side.

*Roger Williams*  
Boulder, Colorado

### Happy Birthday

Happy First Birthday! You took off smoothly and have been flying high ever since. You have provided an interesting, understandable, and highly enjoyable vehicle for someone like me—just a person who loves planes.

*Mrs. M.E. Saunders*  
Accord, Massachusetts

### Dissenting Opinions

As a charter subscriber with 50 years of experience in almost all aspects of aviation, I must say that *Air & Space/Smithsonian* disappoints as it seeks its rightful place as the journal of the National Air and Space Museum.

Articles on non-air and -space topics are better left to *Smithsonian* magazine. *Air & Space/Smithsonian* can shine with a brilliance unmatched by others in the historical field, drawing upon the wealth of the Smithsonian archives. It is almost aggravating to see the extensive use of watercolor illustrations instead of reproductions of the great historical photos in the Smithsonian's files.

The challenge is great, but our respect for the Smithsonian assures us, the subscribers, that your talented staff will meet it.

*David H. Kenyon*  
Sherman Oaks, California

I have been an avid reader of magazines for the past 30 years. I have subscribed to many magazines on aviation and science. So I must take exception to Mr. Longyard's assessment that *Air & Space/Smithsonian* has an identity crisis (Letters, December 1986/January 1987).

There is no doubt in my mind *Air & Space/Smithsonian* is, at the very least, one of the best magazines to which I have ever subscribed. The artwork and articles are superb, and it is one of the few magazines that conveys its value merely at the sight of it. The authors are excellent. Their love of aviation and all related to it filters through the prose to the reader.

*Air & Space/Smithsonian* has caught the very essence of the aviation experience. Not just pictures of machines or speculation on the future, but people. People in and around aviation are brought to life on the

pages of this magazine. If one looks at *Air & Space/Smithsonian* and sees only a magazine, he has missed the gestalt of this publication.

*Richard A. Crane Jr.*  
Mesquite, Texas

### Reaching Out

I have been following your magazine for the past year and have enjoyed it immensely. I usually read your issues cover to cover and have learned a great deal from the variety of subjects you publish, which are to the point and informative. You are to be commended on the subject matter and style of your articles.

An underlying theme that I have observed in each issue is your concern about education, especially in science and mathematics. Don Lopez's article in the December 1986/January 1987 issue was accurate in commenting on the declining quality of education in the U.S. and its effect on the future of aerospace science and technology. Few people realize that the quality of education has allowed the U.S. to prosper since the 1940s.

Generally in schools throughout the country today, the program that receives most of the attention and money is athletics. Don't misunderstand me, athletic programs can be important, but not at the expense of developing minds. Our country needs more than strong backs; we also

need strong minds able to use sound judgment and reasoning.

*David L. Anderson*  
Belle Glade, Florida

### Technology Made Easy

Congratulations to Fred Reed for his excellent layman's explanation of some of the more esoteric aspects of subsonic and supersonic flight dynamics in "The Electric Jet" (December 1986/January 1987).

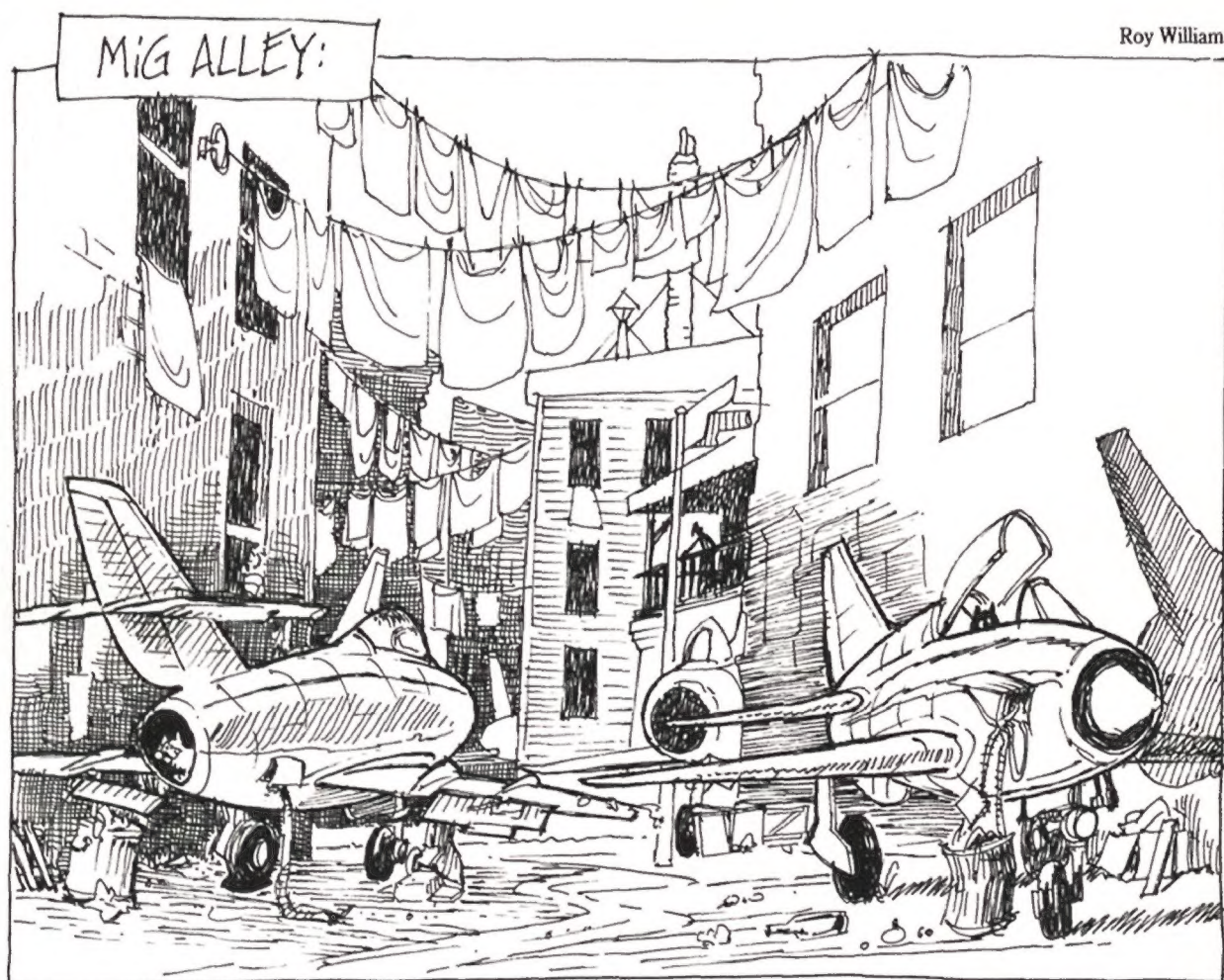
While his work may cause aeronautical engineers to snicker, *Air & Space/Smithsonian* isn't an engineer's manual. It's for people like me, whose nearest approach to supersonic speeds as a pilot has been limited to tearing around the skies at 75–80 mph in a 65-hp Cub 40 years ago.

Great stuff. Keep it up.

*Robert Rogge*  
Radcliff, Kentucky

### The Times, They Are A'Changin'

In the February/March 1987 issue the author of "To Make The Moon More Beautiful" stated that astronaut Dave Scott dropped a hammer and a feather on the moon "to show that they fall at the same rate in reduced gravity." True, they fall at the same rate, but reduced gravity has nothing to do with this experiment. The objects fall at the same rate because the



moon has no atmosphere.

*Jerome K. Layton*  
Paint Lick, Kentucky

In "The Methuselah Project" (February/March 1987), the author incorrectly defines an arc-second. An accurate definition is "the angle the sun moves in the sky in 0.15 second." The article defined it as being "the angle the sun moves in the sky in 15 seconds."

Otherwise, it was an excellent article in your very fine magazine.

*Roger W. Foote*  
Tallahassee, Florida

### Both Ways

In reference to "The Search for L'Oiseau Blanc" (February/March 1987), I would like to make the following comments.

Lindbergh didn't make the first nonstop transatlantic flight. He did, of course, make the first *solo* transatlantic flight. According to the 1928 *Aircraft Year Book*, the \$25,000 Raymond Orteig prize was offered for the first nonstop New York-to-Paris flight, not Paris to New York.

As an aviation historian for over 40 years I doubt very much if glycol was used as a coolant for liquid cooled engines in 1927.

*N.H. Hauprich*  
Greensburg, Ohio

*Stephan Wilkinson replies:*

*I didn't state that Lindbergh made the first nonstop transatlantic flight; I said he made the first such flight between the United States and Europe.*

*Raymond Orteig's original prize offer reads "... prize of \$25,000 [to be awarded] to the first aviator of any Allied country crossing the Atlantic in one flight, from Paris to New York or New York to Paris, all other details in your care. Yours very sincerely, Raymond Orteig."*

*I am not certain whether glycol actually existed in 1927, but what I was referring to was a simple antifreeze mix rather than the proprietary product.*

*Editor's Note: Please see Moments & Milestones on page 92 of this issue for more on Lindbergh's flight.*

*Air & Space/Smithsonian welcomes comments from its readers. Letters must be signed and may be edited for publication. Address letters to Air & Space/Smithsonian, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.*

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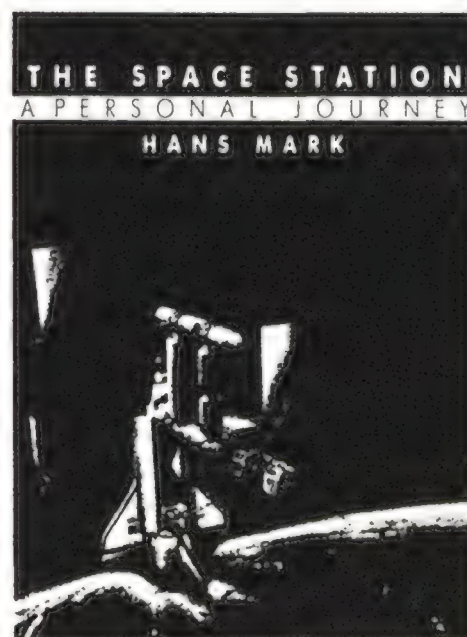
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## THE SPACE STATION A PERSONAL JOURNEY HANS MARK

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## Rendezvous in Near Space

More than 60 years ago, I made a rendezvous in near space, where the unraveling of events was no less dramatic than what has since occurred hundreds of miles above the Earth. Crowds gasped and cameras rolled during our docking just as they did when the Gemini spacecraft rendezvoused with the Agena docking vehicle in 1966.

It was 1926, and I was a freelance pilot flying out of Clover Field in Santa Monica, California. That morning I had enlisted the aid of a friend, Art Jensen, to help service my new Curtiss biplane in anticipation of the weekend passenger business. We had put in gas and oil and checked the Hispano-Suiza engine.

"You grease the wheels while I grab a quick bite," I said, heading for the airport café. Greasing airplane wheels was a simple process in those days. There were no brakes, no roller bearings—a single bolt and hubcap held the wheel onto the axle. Jensen was a conscientious mechanic, and as he was replacing the hubcap and bolt on the left wheel, he noticed that the bolt threads were damaged and would not accept the nut. Muttering under his breath, he removed the bolt and went to look for a replacement in the hangar.

In the meantime, as I finished my breakfast, I was approached by Frank Clark, a fellow pilot who often flew for Hollywood.

"Your ship okay, Jerry?" he asked.

"Yes," I replied, "just had her completely serviced."

"Good," he said, "get up here right away and you can fly the photographer for the airplane change stunt that I'm going to do with Art Goebel and Al Johnson. There'll be a quick twenty bucks in it for you."

The airplane change stunt that Frank had referred to was new and elaborate and the boys had thought it up especially for the Pathé News Reel. I was to carry the photographer into position to record the event.

Back at the flight line, I found my airplane but not Jensen. So I asked one of the other boys to help pull the prop through, and the 180-hp motor soon barked to life.

I taxied up to Clark's hangar. After quick introductions and an explanation of the stunt, the cameraman climbed into the front seat, and I taxied to the east end of the field and took off.

At that moment, Jensen emerged from the rear of the hangar with a new bolt in his hand. When he saw what was happening, he

broke into a run, shouting futilely, "Hey, wait a minute! Stop that plane!"

At 1,500 feet, I banked left, and out of the corner of my eye I saw a flash below and to the left. Banking a little steeper I saw it—a wheel tumbling over and over as it fell to the streets of Santa Monica. *My God, it was my landing gear!*

*Help from above came in the form of a Curtiss JN-4D and a wheel on the end of a rope.*



My predicament was serious: I was airborne with only one landing wheel in a newly acquired airplane in which I had invested everything. Landings had been made with broken wheels and flat tires, but never without one wheel. The axle's stub would dig into the ground on landing and flip the airplane onto its back. Even if I cruised around for an hour to use up gas and reduce the fire hazard, the landing would still result in a broken propeller, a damaged wing, and vertical fin. Since my first duty was to the safety of my passenger, I decided to circle the field and think of some way out of this predicament.

Below me, I saw two men on the landing strip. One held an airplane wheel high over his head and the other crossed his outstretched arms in front of him, signaling me not to land.

A few minutes later, Frank Clark took off with Al Johnson, an expert wing walker and aerial stuntman. After one circuit of the field, Frank maneuvered alongside us. Motioning me to slow down, he pulled ahead and below. In a matter of seconds, Al had scampered out of the cockpit and made his way out along the lower right wing and onto the upper wing. Frank's airplane was close now; he was nodding and signaling. Finally I got the message: come in close so Al can hop aboard.

Reluctantly, I moved in toward Al, my left wing directly over the right wing of Frank's airplane. I felt a sudden addition of weight on the left wing. Al was aboard.

He climbed through the rigging to the step at the side of my cockpit. Leaning in, he shouted over the engine noise, "Hi, Jerry. Cruise around close to the field. They'll bring up a wheel. I'll get it and put it on for you." It was almost casual.

Bob Lloyd, another motion picture pilot, took off with Ivan Unger, a wheel, and 20 feet of rope. Ivan, in his early 20s, was a professional wing walker and parachute jumper, short in stature but long on courage. He had flown with me on many a Sunday show, hanging by his feet from the wing skid or landing gear.

At 1,500 feet and 70 mph Al made an extremely difficult job look easy. Grasping the short strut on top of the upper wing, he nimbly hoisted himself up and assumed a crouching position to await the rendezvous with Bob, Ivan, and the wheel. Soon they approached from behind, slightly above and to my left, and Ivan began lowering the rope, the wheel dangling at its end.

Al reached up an anxious hand for the oncoming wheel. I throttled back a little. The turbulence made it difficult to maintain position, and the dangling wheel bobbed in the rough air. Al reached forward to grab the wheel just as a short, upward movement

of Bob's airplane caused the rope to tighten. Ivan let go of the rope, thinking Al had the wheel. The wheel passed two feet in front of Al's outstretched hands and plummeted to earth, trailing the rope and looking like a comet. My heart went down with the wheel.

The boys on the ground had an idea. It was actually Art Goebel who solved the problem: Why not try a wheel without a tire on it? It would be lighter and offer less wind resistance. Art and Ivan were soon airborne in Art's airplane, old Number 27, with Frank and a newsreel cameraman hot on their heels to record the event for posterity.

Soon Art's airplane approached. I could see Ivan out on the wing with a wire-spoked wheel. Al scrambled back to his position on my upper wing. In a few minutes, I was in close formation with Art. Al reached up, fighting the 70-mph wind blast. He seemed to reach out at just the right moment—and closed his fingers around a handful of wire spokes. Smiling from ear to ear, Al slid down a strut with the wheel in one hand and made his way to the empty axle. Using both hands and feet while engaging the wheel, he worked at it for what seemed an unusually long time.

From my cockpit I could barely see what was going on, but the extended delay bothered me. I sensed trouble. Finally Al came to the cockpit with a worried look on his face. "I can't get the wheel on far enough to put the bolt through the axle. It's the wrong size wheel, and the hub is too damn wide," he hollered.

Without the bolt through the axle, the wheel could slide off in a bank or on landing. While I was pondering the next move, the motor spit, coughed, and died. I glanced at the gas gauge—empty. After a few convulsions, the propeller stopped at a 45-

degree angle.

Al, momentarily concerned by the dead motor, suddenly brightened. "Go on in and land her, Jerry. I'll hold that wheel on with my foot."

He slid back to a sitting position on the lower wing, hooked his right foot under the landing gear strut, and then pressed his left foot hard against the outer hub of the wheel. By exerting constant pressure, he could keep the wheel from sliding off the axle. He gave me the okay signal, and I started my glide downward. I had little choice. With the motor silent and the prop blast gone, we descended in eerie silence. Everything depended on keeping enough gliding speed to maintain control without losing too much altitude too soon before reaching the landing area.

I passed over the trees at the eastern edge of the field as I had done a hundred times before, but never, since my solo flight, was I so concerned about the outcome of a landing. Dropping the nose, I glanced to the right and left, then focused my attention straight down the landing strip. A crowd had congregated to witness the crash, and an ambulance stood by. But the runway was clear for the dead-stick landing.

The right wheel and tail skid touched down, then the bare rim, which screeched along the landing strip. The airplane tried to yaw left, but right rudder corrected it, and we rolled to a stop.

People rushed toward the airplane cheering and yelling. You'd have thought we'd just completed a nonstop Pacific crossing. Everyone was happy, especially Art Jensen, the mechanic, who was still holding the missing bolt in his hand. We had returned safely to Earth from our rendezvous in near space.

—F. Gerald Phillips



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### Airport Links

Passengers landing at Bangkok International Airport may think they've flown into the Twilight Zone when they glance out their window and see golfers strolling by the runway. At the least, it provokes a classic double-take.

Bangkok airport has separate runways for military and commercial aircraft, and between the two is an 18-hole, par-72 golf course. The Royal Thai Air Force, in a particularly ingenious frame of mind, built the course in 1957 to discourage birds from nesting near the runways. "We decided short grass was the solution, and a golf course seemed the ideal way to keep things neat and trim," says an air force spokesman. "Besides, other than at an airport, there are not many places the air force can have its own links."

The course did indeed kill two birds with one stone. Due to the popularity of golf

among middle-class Thais, facilities in and around Bangkok are in high demand, driving civilians and military personnel to the airport course with its inexpensive fees. However, the location makes for a challenging game. Players say it's not the sand traps or usual hazards they mind—it's the out-of-bounds markers, which signify the fairway perimeters.

The course was not quite so challenging until a second commercial runway was constructed a few years ago. That narrowed the width of the course to a mere 200 yards, and out-of-bounds markers sprouted in the middle of the fairways, where one least expected to find them. A ditch separates golfers and aircraft, and a ball hit there costs two strokes.

Authorities say the course presents no hazard to aircraft, and pilots say the golfers are not a distraction, but players have had

to make a few attitude adjustments. "If you're downwind of a 747 that has just landed and thrown its engines into reverse thrust, the ground vibrates, the ball does a jig on the tee, and your head does something similar," says a runway golfer. "You have to wait a few seconds—the noise is deafening. But once the airplane is gone, the silence is so deep by contrast that you can concentrate wonderfully. And it sure adds excitement to the game."

But airport golfing also offers an occasional advantage. "I mis-hit the ball off the tee one day," Mike Majer recalls. "It wasn't one of my better days. But just at that moment a Thai Airways Boeing 737 was rolling along the taxiway, about 20 yards away. The ball hit the undercarriage, bounced back, and landed on the green. I went on to hole out in par. It didn't have any effect on the aircraft, of course, but it

Illustrations by Paul Salmon



made a heck of a difference in my game."

The air force recently opened a new course at the northern end of the airport, and the future of play between the runways is questionable. For the time being, however, one of the world's oddest courses continues to challenge golfers and discourage birds. Indeed, pilots say bird strikes are rare at Bangkok airport. There are, however, occasional eagles and birdies.

—John Hoskin

## The Star Attraction

On the Saturday of the United States Naval Observatory's annual open house, Secret Service men stood in front of the main building, their suits, shades, and radio earplugs as subtle as black-tinted glass on a stretch limo. Something was up. Sure enough, with a roar of blades and considerable rotor wash, a huge Sikorsky VH-3D Marine helicopter swooped down to pick up Vice President George Bush.

The observatory, in Washington, D.C., shares its grounds with the official vice presidential residence, so Bush sightings here are fairly routine. But according to observatory spokesperson Gail Cleere, they can be a distraction for visitors. "We have people who are absolutely thrilled to be looking at Saturn through a telescope, and then all of a sudden we lose the crowd to the windows," she said.

In its earlier days, the observatory did not number vice presidents—no matter how stellar—among its attractions. There wasn't even any astronomical activity. In 1830, the naval observatory began as the Depot of Charts and Instruments, charged with the task of storing the Navy's maps and navigation equipment. In 1844, when its duties expanded to include astronomical studies, the facility moved to a new home near the banks of the Potomac, close to the present-day location of the Kennedy Center. Unfortunately, nearby swamps made the site less than ideal for astronomy: chronic fog limited observations, and the marshes proved to be a breeding ground for malaria-bearing insects. In 1893, the observatory moved to its third location, just up the street from Embassy Row, where it has remained since.

The observatory today is concerned mostly with measuring the passage of time and the distance between objects in space, information necessary for navigation and communications. Transit circle telescopes, focused exclusively along the arc of a meridian, precisely chart the positions of the sun, moon, planets, and stars for celestial coordinate systems. And the observatory's Master Clock keeps the accurate time necessary for global

navigation systems.

In the past, the observatory's telescopes were on astronomy's cutting edge. When it was acquired in 1873, the 26-inch telescope was the largest refracting telescope in the world, and with it Asaph Hall discovered the tiny moons of Mars. Today the observatory's optical instruments have been left in the dust by technological advances in the field, and the 26-incher is now used mainly for the observation of double-stars. Astronomer Thomas Corbin told a group of open-house visitors at the telescope, "We make mostly a series of observations to get better values for things that move."

The observatory is open each Monday night on a first-come, first-served basis, but the day-long open house comes only once a year. "People want to get in here and take a look around," Cleere said. "We can't do it every day, because we wouldn't be able to get any work done."

The 2,000 or so attendees at the 1986 open house were not your run-of-the-mill



tourists. They planned their visit well in advance, and were quite willing to wait in line to use the telescopes and ask questions. These were the sort of people who bundled up last winter to stand in a field with binoculars and look for Halley's Comet—for amateur astronomers, patience is a mandatory virtue.

The 26-inch telescope was the big draw at the observatory's open house. A long, white, slightly age-worn cylinder that stares through a slit in the domed roof, it attracted a number of families who wanted a peek at Procyon, one of the 10 brightest stars visible to the naked eye. The telescope can't be raised or lowered without shifting its field of vision, so the mountain has to go to Mohammed. At the touch of a button, the entire wooden floor of the telescope room rises or falls—creaking, groaning, and whining—bringing

the eye to the eyepiece. It's cumbersome, but it works.

Not everyone was impressed at the sight of Procyon. "It was just a white dot," a little girl complained to her mother.

The 24-inch reflecting 'scope wasn't looking at anything at the time, so there weren't any lines. But astronomer Bob Harrington put the telescope through its paces, operating motors to make it swivel and pivot. "TV people love it," he told two amateur astronomers. "It's the only one that makes a decent noise."

Elsewhere on the grounds, smaller telescope domes sprout like far-sighted mushrooms. Fathers and mothers explained the workings of telescopes to sons and daughters. On the lawn, visitors saw sunspots through a refracting 'scope set up by the National Capital Astronomers.

In the Simon Newcomb Building, visitors learned about the measurement of "a nonspatial continuum in which events occur in apparently irreversible succession from the past through the present to the future," better known as time. This is the headquarters for the world's most accurate clock, actually a system of 24 atomic clocks that measure the rates at which cesium electrons change state. (The outer electron of the cesium atom moves from one energy state to another precisely 9,192,631,770 times per second.)

The cesium clocks, backed up by hydrogen maser devices for even more precise short-term measurements, are compared with each other to produce an average that's accurate to one nanosecond—one one-billionth of a second—per 24 hours. The Master Clock time is the standard for navigational systems like Loran-C and NAVSTAR, for which time is of the essence—a 10-nanosecond error would translate to a 10-foot deviation in Loran-C navigation. At that rate, a one-second error would mean an error of about 200 miles.

The Newcomb building also houses the Master Clock Telephone Announcer, a recorded voice that relentlessly marks the passage of time every five seconds. Visitors hearing the announcements reflexively check their watches and make necessary adjustments. "I'm only three seconds fast," said one man with obvious satisfaction, perhaps oblivious to the fact that his watch was off by three billion nanoseconds, or three *trillion* picoseconds.

In the main building, trillions of nanoseconds passed while visitors waited to look through the 12-inch refractor. Originally installed in 1895, it was retired in the 1950s but was overhauled and called back into service in 1980. Like the 26-inch 'scope, the 12-incher is focused on a star—

our sun. Peeking through the eyepiece, viewers see hydrogen flares bursting from the sun's surface 93 million miles away. It's a more impressive sight than either Procyon or George Bush. The vice president's Secret Service men might agree: according to the telescope's logbook, they spent a few minutes to sneak a peek at the sun while waiting for their charge.

—Tom Huntington

## Highway Fliers

It's difficult to envision an aerodynamically efficient truck. In terms of windblown science, a tractor-trailer rig is at the bottom of the evolutionary ladder, a packing crate on wheels. Nevertheless, aerodynamics have shaped the trucking industry, thanks in part to the pairing of an Indy racer and a Corvette designer.

Roger Penske, the owner of the most successful team in Indianapolis-type car racing, decided in 1983 that he needed a high-tech transporter for his race cars. Penske approached Larry Shinoda, a former Chevrolet designer credited with the Corvette Sting Ray of the early 1960s who had since gotten into truck design. Like an operator of an airline or air freight operation, Penske wanted a faster cruising speed and better fuel efficiency. The tractor-trailer rig that Shinoda & Associates in Livonia, Michigan, created for him not only does the job, but also provides a look at the leading edge in truck design.

Shinoda fought an uphill battle from the start. The combination of blunt-nosed Freightliner tractor and 48-foot Great Dane trailer creates the turbulence of a microburst. As the rig barrels down the highway, air flows around the tractor, strikes the trailer, and degenerates into a mass of confused currents symptomatic of drag. You can see the result during a rainstorm. Wrapped in a blinding swirl of spray, the average rig looks like a rogue car wash, angrily hosing down passing autos. The squared-off bow of a tractor-trailer combination has twice the drag characteristics of a car due to its shape alone, and its larger area makes the total drag of a truck even worse.

Shinoda's design incorporates three major elements. The area below the front bumper is carefully sculpted to smooth airflow over the tires. The roof deflector above the cab is expanded to direct airflow across the gap between cab and trailer, which is further minimized by 32-inch extenders mounted on the sides of the cab. And fender skirts for the tractor wheels minimize drag in crosswinds.

The impact of these modifications was immediately apparent. Straight-line stability

improved and cruising speed rose 6 mph. Engine exhaust temperatures declined, indicating a lighter load on the engine. Fuel economy increased 22 percent. And reduction in wind noise enabled the driver to hear his stereo a lot better. Wind tunnel tests revealed that Shinoda's design had slashed drag by about a third.

A number of similar innovations in truck aerodynamics have recently been implemented by Freightliner, Fruehauf, General Motors, and Kenworth. But Penske Racing's black-and-chrome transport is the snakiest design on the road today. Trucks haven't flown yet, but thanks to Larry Shinoda, the phrase "aerodynamic truck" is no longer a contradiction in terms.

—Michael Jordan

## Barnstorming with the Concorde

Anyone with \$895 to spare can now take a supersonic ride to nowhere aboard a Concorde SST. Carriage Trade Travel, a travel agency in Vancouver, British Columbia, is selling two-hour "Discovery Flights" aboard a chartered Air France Concorde, complete with champagne, caviar, and speeds beyond Mach 2. It's barnstorming, but on a grand scale.

Randy Parihar, owner of Carriage Trade Travel, initiated the flights during last year's World's Fair in Vancouver. Five flights were scheduled, and a total of 500 seats sold like crêpes, creating a standby list of 240. Six flights were then scheduled for January out of Oakland International

Airport in Northern California, and all seats sold out. Now on a roll, Parihar is planning flights from Southern California in early April, from Montreal and Toronto in June, and again from Vancouver in August.

Parihar is a native of Fiji and a former sales representative for Qantas Airlines. He first flew on the Concorde eight years ago and saw a unique market aborning. He correctly surmised there would be a good number of high rollers who want to experience supersonic luxury but balk at paying \$2,148, New York to Paris, to get it.

"Just look around you," he said at a recent preflight breakfast for the press, passengers, and crew in Oakland Airport's Tower Lounge. "Have you ever seen so many happy faces?"

Indeed, it was a cheerful group that boarded the Concorde on the morning of January 8. Passengers who dressed as if they were boarding a Greyhound to Fresno were outnumbered by those in mink stoles and tuxedos. A few retirees, such as Nathan Stork, a former airline captain, wore Hawaiian shirts that were best viewed through sunglasses. "In one hour, we'll be almost at Hawaii," Stork said. "Just in case we overshoot, I'm all set for the beach."

"It's about as close to heaven as I'll ever get," said George Burnley, a retiree from Alameda, California. "All it takes is money." Bea Stone got a microwave oven and a Concorde flight for Christmas. One woman, who didn't go, advised her husband as he boarded, "At that price, eat everything." "But I don't like caviar," he said. "Eat it anyway," she replied.



The world's fastest digital integrated circuit, a gallium arsenide (GaAs) chip that runs at a clock rate of 18 gigahertz (GHz), or 18 billion cycles per second has been built by Hughes Aircraft Company scientists. The ultra high-speed circuit operates as a divide-by-two frequency counter and is five times faster than currently available GaAs integrated circuits and ten times faster than commercial silicon circuits. Fastest frequency reported previously for static frequency dividers was 13 GHz for a laboratory device requiring cryogenic temperatures; the Hughes circuit operates at room temperature. Operation of digital circuits at multi-GHz frequencies opens new areas of digital communications and signal processing, promising better noise immunity, a wider range of functions, and less complexity than their analog counterparts. Applications are foreseen in fiber optic communication links, supercomputers, advanced radars, and satellite communications.

Ships at sea will be able to determine their positions via satellite. A maritime navigational system is one of the new services proposed for the existing system of Marisat satellites, launched in 1976. For the past 4 years, the trio of Marisats has been providing telecommunications services for the International Maritime Satellite Organization (INMARSAT), a cooperative of 47 countries that operate a worldwide system for maritime communications. Leases with INMARSAT have been renewed for three years by Comsat General Corporation, owner of the satellites, enabling the Hughes-built satellites to continue providing communications services to the military, shipping, and offshore industries.

A unique computerized visual system helps military forces simulate battlefield terrain. The system provides unusual realism and flexibility to help with a wide range of training and mission planning requirements. It can generate lifelike three-dimensional scenes from a computer database created with aerial photography. Pilots can use the system for nap-of-the-earth flight training, even to the point of seeing simulated radar and infrared displays. The Hughes system also can be used for intelligence analysis and team tactics training.

A night vision system for helicopters significantly reduces pilot workload by eliminating wasted movements, simplifying controls, and providing excellent video images and object detection in reduced visibility. The Hughes Night Vision System (HNVS) is a low-cost, forward-looking infrared (FLIR) system that provides a pilot with automatic tracking and digital video processing. It superimposes FLIR video, flight symbology, and navigational data on a single display, which can be mounted on the flight panel or in a helmet visor. The helmet visor display projects a FLIR image onto a biocular holographic combiner on a see-through visor. A helmet linkage, which moves the FLIR as the pilot's head moves, reduces the pilot's workload further and improves flight safety.

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Air France flight 4989, Oakland to Oakland, left just after noon. "We were at 27,000 feet about 10 miles off the San Francisco coast," said passenger Dave Follis. "In nothing flat we were up to 50,000 feet and Mach 2."

Two hours after departing Oakland, flight 4989 was back. An exuberant trail of passengers deplaned, some wielding empty champagne bottles and any other mementos that weren't fastened down. "It was a good party," announced a passenger. "The food was good," Burnley reported, "there just wasn't enough of it."

"If I had the bucks, I'd go on the next two flights," said Brad Nelson. "This is as close to outer space as I can get, so I had to go. I could hardly sleep last night, just waiting for today."

Others at the airport were content to watch the spectacle from a distance. Said one woman, who didn't take the flight, "I just came to see what kind of people would pay \$900 to go nowhere."

—Elaine de Man

## NASA Puts the Frills Back in Flying

How do you create ideal living and working conditions for eight people confined to a noisy 14- by 40-foot room for three months? Which colors keep people alert, and which soothe and encourage sleep? What type of lighting stimulates activity in the workplace? How much must noise be dampened to create the illusion of privacy? And how do you make a small room seem spacious and inviting, particularly when its occupants can't leave it?

Yvonne Clearwater and the Habitability Research Group want answers to these questions. Their task is to define what "habitability" means in space—to find out how an environment affects productivity, performance, and a sense of well-being in space station astronauts.

The National Aeronautics and Space Administration (NASA) hired Clearwater, an environmental psychologist, to make its space-based workforce not just more comfortable, but more productive. NASA estimates that an astronaut's indoor labor is worth \$30,000 to \$50,000 an hour, and double that for outdoor labor. The agency can't do much to make the exterior environment more hospitable, but the design of the modules that will house its laborers will be heavily influenced by the human factor.

"If astronauts can't get a proper amount of sleep because there's not enough protection from noise, visual stimulation, or stress, and they are 50 percent less productive the next day, that's an



enormous loss," Clearwater says. A design that robs even 20 minutes from each workday wastes \$1 million in labor during a three-month mission.

Clearwater, who helped design underground missile sites to house 300 people, heads a team of 28 specialists in a wide range of technical disciplines. The group, based at NASA's Space Human Factors Office at Ames Research Center in Mountain View, California, has studied data from other isolated environments, from Antarctic research stations to Soviet space stations in which cosmonauts have spent more than 200 days.

"Humans are hardy," Clearwater says. "They can adapt to almost anything for short periods of time. But anything over 30 days is considered a long-duration mission. Behavioral changes, such as intelligence impairment, apathy, and sleep disturbance, have appeared in isolated environments."

Three Skylab astronauts drove the point home in 1974 by staging an orbiting work slowdown. Citing an unmanageable workload, they ignored NASA ground control and spent an entire day photographing the Earth or working on favorite experiments—in essence, doing whatever they pleased. They also complained about the lack of a private area where they could get away from work and one another. And they were annoyed at

being awakened repeatedly by others' visits to the bathroom.

To avoid a repeat performance by future crews, Clearwater and her team are exploring soundproof sleeping areas, private rooms that can accommodate a quick change of clothes, and brightly colored work stations. "We think we understand color and lighting problems," Clearwater says. Now the challenge is to put that understanding into use. "We can't talk about making an interior pretty and pleasant—that doesn't mean anything to an engineer." The research is being used to write guidelines for use by U.S., Japanese, and European space station designers.

Bold, primary colors should accent living and working areas, the group learned, and floors and ceilings should be consistently identified by specific colors. Humans orient themselves to "up" and "down" by color brightness, not lighting, according to industrial design specialist Richard Coss. Astronauts report that the gravity-bound concept of a floor and ceiling helps prevent disorientation and perhaps space sickness. Painting the interior of a module dark blue ("below") fading to light blue ("above") may create the desired effect.

Clearwater thinks that Habitability Group specialists should try a 90-day mission aboard the space station. "We need to send trained observers into space who

# Can You Build the Wright Flyer?

Many tried and failed, but Orville and Wilbur Wright built the first successful aircraft. That famous flight at Kitty Hawk, North Carolina in 1903 was big news to a world that had never before seen a piloted, gas powered airplane.

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can study responses to the environment. It only makes sense to send an environmental psychologist and a design professional."

Though most of the Habitability Group's work will see fruition only on the high frontier, Clearwater says that it can be applied to situations on Earth, where population pressures are forcing people to live and work in smaller areas. Like designers of the space station, which will be staffed with astronauts of various ethnic backgrounds, "we have to plan for privacy for multicultural groups."

—Jane Ferrell

## A Stone's Throw from Mars

Considering how much tabloid newspapers love stories of the extraterrestrial, it wouldn't be surprising to see a headline declare "Meteorite from Mars Hits Earth, Kills Dog." But this is one case of fact beating fiction to the punch line.

The culprit is one of eight meteorites that outwardly have little in common. One dropped onto the French village of Chassigny in 1815. Four are called shergottites, after the one discovered near Sherghati, India, in 1865. Three fell to Earth in 1911 at Nahkl, Egypt (and yes, one killed a dog).

Among the thousands of known meteorites, the shergottite, Nakhla, and Chassigny stones—collectively called SNCs, or "snicks"—are unique. Unlike other meteorites, which crystallized from hot magma and vapor some 4.6 billion years ago when the solar system formed, these have been isotopically dated at a youthful 1.3 billion years. They also contain a unique combination of oxygen isotopes found nowhere else on Earth, the moon, or in other meteorites. The shergottites, in particular, endured a strong shock about 180 million years ago, and the mixture of nitrogen isotopes trapped within them is strikingly similar to that found in the Martian atmosphere by Viking spacecraft.

Confronted with such perplexing data, several years ago scientists finally dared to ask, "Could the SNCs be fragments of rock blasted from the surface of Mars?" The answer seems to be yes, though the case is hardly ironclad. To be so young, their "launch pad" could not have been Mars' original crust but rather a more recent covering of volcanic material. In addition, cosmic ray damage, which increases with time spent in space, has had little effect on the meteorites' crystal structure, suggesting that the trip from Mars to Earth was relatively brief—between 400,000 and 12 million years, depending on the sample. Whatever their origin, the meteorites had solidified into rocks long before beginning



their journey to Earth.

Conceivably, the stones could have been rocketed from Mars during a single giant impact or two or three smaller ones. But cratering specialists have argued all along that the sheer energy of such a cataclysm would have melted any ejected debris long before it reached Mars' escape velocity of 11,200 mph. Because the age of a rock can be calculated only from when it was last molten, not from when it originally solidified, such an event would have reset the minerals' geologic clocks to 180 million years instead of the observed 1.3 billion.

Now a pair of geophysicists at the California Institute of Technology in Pasadena thinks there is a way to get rocks off Mars intact during an impact, but the conditions must be just right. Thomas Ahrens and John O'Keefe first took aim at the problem with a quartet of high-velocity research guns in the basement of Caltech's geophysics laboratory. The largest, 106 feet long, can fire one-ounce plastic bullets at more than 16,000 mph. Such tests, which shake the building, provide crucial insights into the behavior of rocky material during a catastrophic impact.

After deriving the equations for a simulated Martian surface, O'Keefe and Ahrens calculated how the trajectory of an incoming object affects the spray of debris produced by the blast. They found that hitting Mars obliquely can create jets of white-hot vapor that rapidly move outward. The effect is greatest at an angle 25 degrees from the horizontal. Such a glancing blow can spew out a vaporized jet

moving at more than twice the speed of the colliding object.

Perhaps most importantly, chunks of rock that chance into the path of the vapor jet can be accelerated to escape velocity without being destroyed in the process. For example, an asteroid one mile wide striking Mars obliquely at 18,000 mph—a typical impact speed—can send rocks six inches and larger flying into space. Larger blasts yield larger fragments. Of course, the far-flung rocks must then somehow make their way to Earth, but that's another problem. For now, O'Keefe and Ahrens are happy enough to have found a way to get them off Mars in one piece.

—J. Kelly Beatty

## Update

**In yet another mating of aerodynamics and yacht design** ("Soaring on the Sea," February/March 1987), an experimental drag reduction film borrowed from a NASA research program may have helped *Stars & Stripes* win the America's Cup. The racer's hull was covered with a thin plastic film scored by small V-shaped grooves called "riblets," which reduce skin friction drag. Some yachtsmen estimate that the film added as much as 0.2 knot, or 0.17 mph, to *Stars & Stripes*' speed. Sheets of the plastic, which is produced by the 3M Company, have been applied to the skins of a Learjet and a Lockheed T-33, reducing drag by eight percent. 3M plans to offer the film to the sailboat racing community this spring.

### Orbital Sciences Corporation

("Entrepreneurs in Space," December 1986/January 1987) got a Christmas present from NASA in the form of an agreement to purchase a second Transfer Orbit Stage (TOS), which will be used for a communications satellite. (The first TOS is slated for a Mars Observer mission, now postponed until 1992.) The good news called for the continuation of a tradition begun by company founders David Thompson and Bruce Ferguson, who had taken to jumping in a lake to celebrate business milestones. Co-founder Scott Webster expected to take the plunge last summer, but NASA did not come through with the contract until December. Clad in a wet suit, a stoic Webster dove in on the day after New Year's.

### Taylorcraft Aviation Corporation,

which moved into the abandoned Piper facility in Lock Haven, Pennsylvania, last spring ("Hard Times in Hangartown," April/May 1986), is now for sale. George Ruckle, who led the effort to resurrect the classic Taylorcraft design, is in poor health and is planning to sell at least 51 percent of the company.

**Aviator Beryl Markham** was not the author of *West with the Night* (Moments and Milestones, June/July 1986), claims Scott O'Dell, an acquaintance of Markham and her third husband, Raoul Schumacher. In a letter to *Vanity Fair*, O'Dell says Schumacher confided to him in 1942 that he was the author of Markham's memoirs. Rumors to that effect have been circulating for years, particularly since republication of the book in 1983, followed by a long stint on the best seller list.

**The crash of a Pakistan Airlines F-27** Fokker transport in Peshawar last October may have been due in part to the rowdy celebrations of a group-wedding party near the airport. A Karachi newspaper reported that seven bridegrooms were arrested for "lethal celebrations" that included rifle fire, which may have hit the aircraft or distracted the pilot.

### Two Transcendental Meditation

**organizations** were found liable for fraud and negligence in promising 36-year-old Robert Kropinski he could learn to fly, or in TM terms, self-levitate. The plaintiff, who sued for \$9 million, claimed that during his 11-year association with the organizations, students learned only to "hop with the legs folded in the lotus position." A jury in a Washington, D.C. federal court awarded Kropinski \$137,890.

—Patricia Trenner



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## The Farm

On a bright winter morning in 1942, I died. I presume I was killed instantly, smashed into the frozen ground right near the airport at Helena, Arkansas. I'm vague about the details of what I hope was considered, at least momentarily, a tragedy. I do feel very sad about it: a flying cadet in his early twenties, enthusiastic if mediocre, a congenial companion, loving son and brother, reduced to a smoking crater in a plowed field.

I do know what led up to my death. I've been going over it in my mind for years.

Helena had a primary flight school for the Army Air Corps. Its field was lined with Stearman PT-17s, beautiful biplanes with blue fuselages and yellow wings bearing the old-fashioned rondel and star. The cadet hierarchy was as simple as the Army could make it. Underclassmen who hadn't soloed had to wear their goggles around their necks, dangling below their chins. And they were subjected to some hazing, which, in my case at least, had been rather perfunctory and often quite funny. As an upperclassman, I no longer had to plaster myself against the wall in a rigid "brace" whenever a superior strode past. On the morning in question, I walked out to my airplane with my goggles up on my forehead, where they belonged.

"Go work on your acrobatics," my instructor had said. Our instructors were mostly former crop duster pilots, accustomed to cruising three feet off the ground. You can't slop around down that low, so these pilots had always been demanding of both themselves and of us: the tachometer should read 2,250 rpm, not 2,253; keep the ball *exactly* in the center.

I strapped myself into the open cockpit, pulled down my goggles, turned the fuel valve parallel to the fuel line—the "on" position—and cracked the throttle. The crew chief stood to the left of the engine, facing the propeller, inserted the starter crank, and applied himself to the task. The flywheel spun, its sound gradually rising from a low moan to a keening wail. The crew chief then disengaged the crank, yanked the engager, and stepped back.

I yelled "Contact!" and snapped on my

switch. Blue smoke swept past me as the engine caught. I fishtailed downwind to the runway's end, stopped to check the engine, got a green light, and soared into the crisp morning.

There was a special place where I liked to besport myself: a farm with an attractive, tree-shaded house in which, I fictionalized, lived a daughter who looked like Rita Hayworth and whose heart thumped with passion whenever I flew overhead.

For most of an hour I did my best for her: slow rolls in which I only fell off a little, loops that were nearly straight, recoveries from spins that were off by only a few degrees, snap rolls that weren't very good, split-S's that were quite good (a split-S is pretty easy).

I combined two loops with two Immelmans to produce a vertical figure eight and, to my joy, managed to hit my own slipstream. God, I hoped Rita Hayworth had seen *that!* After about 50 minutes I waggled my wings at the house (there was no answering wave) and headed for the barn. The plane hummed sweetly to itself, as though it had enjoyed the workout.

I got the green light on downwind, swung onto base leg, nose down, engine gurgling, turned again onto approach—we called it "approach" back then, not "final"—jazzed the throttle once, to clear the engine, eased back . . . back into the gut . . . quick with the rudder . . . And greased her on, tail first, the way my instructor had wished for so long that I would.



Delighted with myself, I taxied to the line, pulled up in place, and braked to a stop. To shut down, you turned off the fuel, then slowly opened the throttle as the engine starved. And when the prop came to a stop you switched off. I reached down for the fuel valve to turn it off.

It was already off.

Instead of being aligned with the fuel line, it was perpendicular. I touched it. I leaned over and stared at it. And as the engine started to die, I opened the throttle; the engine cut off, the prop stopped, and I turned the switch and shouted "Switch off!"

I looked down again at the closed fuel valve. Without fuel the plane couldn't fly. And the fuel was cut off, but I hadn't turned it off.

The sound of a distant radio in the hangar reached me: "I Don't Want to Set the World on Fire." A classmate, headed for his airplane, waved a gloved hand at me. I undid my belt and stepped out. I peered back into the cockpit. There was the fuel line, and there was the handle turned across it. Off. And I hadn't turned it.

The valve wasn't all that easy to turn. It moved from one precise angle, open, to the other, closed. It couldn't have closed from vibration or the acrobatics. And with the valve closed, the engine would have starved in about four seconds.

So I hadn't made that splendid flight at all. I'd died. I don't know exactly when. Maybe I had closed the valve with my boot and augered in on Rita Hayworth's farm. As I say, I don't know the details.

I do know that in my case, being dead is just an extension of being alive. I've been dreaming along for 45 years, savoring what my life would have been like had it not been cut short so pathetically. I've gone along, making a living and paying taxes and raising a family. But it's all in my head, you see. It's not real.

That's why, on rare occasions, I do dumb things—they're not real. Neither is my wife. I told her my story, and she listened a little distractedly while getting breakfast. "I always knew I was an angel," she said, and poured the coffee.

—Edwards Park

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## Anniversaries...

**1919**

**May 29** Two British expeditions collect data from a solar eclipse that confirm a crucial prediction Einstein made in his general theory of relativity: space is warped by the gravitational effects of large bodies. The eclipse proved that the path of starlight is bent by the sun's gravitational field as is the path of any other mass, and public adoration of Einstein began shortly after confirmation was announced in November.

**1920**

**April 27** The first U.S. warrant for "reckless aerial driving" is issued in Los Angeles. The complaint, brought by the Aero Club of Southern California, named airshow and movie stuntman Ormer Locklear as the wayward aviator.

**May 7** At the first intercollegiate air meet, held at Mitchell Field on Long Island, New York, in Curtiss JN-4s, Yale won with nine points and Princeton and Columbia tied for third place. Harvard, Cornell, Rutgers, and Wesleyan also competed.

**1923**

**May 2** U.S. Air Service test pilots Oakley Kelly and John Macready depart from Long Island in a Fokker T-2 single-engine monoplane in their third attempt to make the first nonstop transcontinental flight. The first two had originated on the West Coast, where the airplane, heavily loaded with fuel, was unable to climb over the mountains. They used a mile and a half of runway on their Roosevelt Field takeoff, and arrived at Rockwell Field in San Diego 27 hours later, having flown at an average speed of 92 mph.

**1926**

**May 20** President Coolidge signs the Air Commerce Act, requiring aircraft and pilots to be licensed and spelling the demise of the barnstorming era.

**1931**

**May 27** The National Advisory Committee for Aeronautics opens a full-scale wind tunnel at Langley Field in Virginia. Two

35-foot propellers, driven by 4,000-hp motors, moved air at 110 mph in the 60-foot-wide tunnel.

**1933**

**April 3** Two British Westland open-cockpit biplanes make the first flight over Mount Everest and photograph the highest point on Earth. Their maximum altitude of 30,000 feet leaves little margin as they cross the 29,028-foot peak.

**1934**

**April 12** Three weather observers witness "the strongest natural wind ever recorded on the Earth's surface," 231 mph, on Mount Washington in Gorham, New Hampshire. The year-round weather observatory on the 6,288-foot peak records consistently high gusts due to elevation and local topography. Employees of the facility, who are on eight-day shifts, also work with developers of weather instruments and study cosmic ray activity.

**1950**

**May 9** Construction of permanent Air Force launch facilities begins at Cape

Canaveral. Under a \$258,000 contract, Duvall Engineering of Jacksonville built a concrete launch pad and an access road from Highway A1A. The first pad, which was used only for testing, is no longer operational. The Air Force station now has six operational pads and another under renovation. Additionally, NASA maintains two launch pads and a landing runway for the shuttles. The two agencies and their hardware share the Cape with the denizens of the Merritt Island Wildlife Refuge, established in 1963.

**1952**

**May 2** De Havilland's D.H. 106 Comet, the first jet airliner, enters commercial service with British Overseas Airways.

**1954**

**April 1** Construction of the Air Force Academy is authorized. The four-year curriculum required 1,548 hours in the humanities, 1,629 hours in science, and 2,178 hours of airmanship.

**1959**

**April 2** NASA selects seven Mercury

*Mercury astronauts flew Mach-2 F-106s while preparing for their launches.*

NASM



astronauts from a group of 18 candidates. In December 1960, Mercury project manager Robert Gilruth asked the seven pilots to write down their choice—other than themselves—for pilot of the world's first manned space flight, set for May 2, 1961. It was announced in February that Alan Shepard, Virgil Grissom, and John Glenn were the final candidates. On April 12, cosmonaut Yuri Gagarin preempted the first Mercury mission with a single orbit of Earth. On May 5, Shepard made what Nikita Khrushchev described as a 15-minute "flea hop" of 116.5 miles.

#### 1960

**April 1** TIROS 1, the world's first weather satellite, is launched. TIROS (Television and Infrared Observation Satellite) provided more than 22,000 pictures of the Earth from an average altitude of 515 miles. Nine more TIROS satellites were launched through 1965.

#### 1961

**May 20 & 21** The Air Force opens its Cape Canaveral launch facilities to the public during a "drive through" on Armed Forces Day, which was attended by an unexpected and enthusiastic crowd of 60,000. Traffic jams, overheated cars, and short tempers resulted.

#### May 25

President Kennedy tells a joint session of Congress that "this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth." He did not live to see his goal achieved in 1969.

#### 1962

**April 26** *Ariel 1*, the first international satellite, is launched by NASA from Cape Canaveral. *Ariel 1* contained six British atmospheric, solar, and cosmic ray experiments. On July 8, an experimental hydrogen bomb code-named Starfish was launched from an Air Force station on Johnston Atoll in the Pacific and exploded at an altitude of 248 miles, within 4,600 miles of the satellite, saturating the instruments and solar cells with radiation. Most of the instrumentation continued to work, but the solar cell damage resulted in erratic operation of the satellite for the remainder of its two-year functional life.

#### 1970

**April 13** An oxygen tank on the Apollo 13 service module ruptures en route to a lunar landing and damages a second tank and the three fuel cells. Astronauts James Lovell, Fred Haise, and John Swigert moved into the lunar module for an early return to

Earth, and for three days they lived on less than a quart of water and slept in near-freezing temperatures. The crew returned to the command module for splashdown after jettisoning the lunar and service modules. Lovell later called the accident "the \$375 million failure."

#### 1973

**April 16** The Florida senate votes 37 to 0 to restore the name Cape Canaveral to the area renamed Cape Kennedy shortly after the president's assassination. Canaveral, a European word meaning reedy or grassy, first appeared here on Spanish maps of the prominent Florida cape in the 1540s. A countrywide storm of protest had greeted the The Board on Geographic Names' overnight decision to change the historic name in November 1963. Government agencies passed the buck for the next 10 years until the board agreed to reinstate the name in October.

**May 14** Skylab is launched from Cape Kennedy. Manned three times by crews who remained for up to 84 days, Skylab's orbit decayed prematurely in 1979. Increased solar activity caused Earth's upper atmosphere to expand, which increased drag on the spacecraft.

#### 1982

**April 19** The Soviet Union launches the Salyut 7 space station to replace the aging

Salyut 6. The first six stations were "deorbited" and disintegrated in the atmosphere or fell into the Pacific Ocean when they were deemed no longer useful. Salyut 7 is now in what the Soviets call "storage mode," leaving the Mir station as the lone active facility.

#### 1984

**April 11 & 12** The crew of the shuttle *Challenger* retrieves, repairs, and relaunches the scientific satellite Solar Max, the first designed for field repairs. Since then, a tape recorder and an antenna bearing have failed. NASA hopes that what remains of the solar research satellite will function until 1991.

## ... and Events

#### Through April 26

"Jupiter and Its Moons," Smithsonian Traveling Exhibition. At Sandor Teszler Library Gallery, Wofford College, Spartanburg, SC, (803) 585-4821.

#### April 4–May 3

"Twenty-five Years of Manned Space Flight," Smithsonian Traveling Exhibition. At New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

#### April 10–12

International Space University Spacefair '87. An international project to encourage and expand space-related education and research. Planned to begin as a summer session and expand to full-year format, a dedicated campus, and orbital facilities in the early 21st century. At Massachusetts Institute of Technology, Cambridge, MA, (617) 253-8897.

#### April 11

Bay Area Airline Historical Society Convention. Slide show, door prizes; buy, sell, or trade airline collectibles. At San Francisco International Airport Holiday Inn. BAAHS, (415) 574-8111.

#### April 13–May 12

"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Tuskegee University, Tuskegee, AL, (205) 727-8346.

#### April 17

The Great Delaware Kite Festival. Held yearly on Good Friday, this competition draws well over 2,000 spectators. At Henlopen State Park, Lewes, DE, (302) 684-8576.

*Apollo 13 astronauts are paraded through Chicago after a touch-and-go mission.*



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**April 21-24**

"Space: The Challenge, The Commitment," 24th Space Congress. Exhibits, youth science fair, "meet the astronauts" panel, banquet. Canaveral Council of Technical Societies, Cocoa Beach, FL, (305) 783-0220.

**April 22**

Lyrids meteor shower, two to three hours before sunrise. \*

**April 23-25**

National Intercollegiate Flying Association's 39th Annual Safety and Flight Evaluation Conference. Twenty-four flight teams from colleges and universities across the country will compete in precision flying events. Carbondale, IL. Contact Terry Bowman, (618) 536-6682.

Middle Atlantic Planetarium Society Annual Meeting. Observation workshops, exhibits, field trips, concert, banquet, night observations. At Vanderbilt Planetarium, Centerport, NY. Contact Tom Carey, (516) 757-7502.

**April 24-26**

Fifth Annual Wright Brothers Fly-in. For its first four years, this event was called the Wilbur Wright Fly-in—its organizers felt that Orville, who made the record books as the first to fly, was getting all the glory. However, so many asked "Why Wilbur?" that the First Flight Society changed the name and won a little peace and quiet. At Wright Brothers National Memorial, Kill Devil Hills, NC, (919) 441-3761.

"Aviation History, Technology, and Restoration," "The Golden Age of Flight," and "Behind the Scenes at the National Air and Space Museum," seminars by National Air and Space Museum curators. At Experimental Aircraft Association Museum, Oshkosh, WI. Smithsonian National Associates, (202) 357-1350.

**May 1-3**

Sailplane Aerobatics Association's Second National Championships. Stillwater, OK. At Estrella Sailport, (602) 568-2318.

Third Annual Air Racing History Symposium. Films, exhibits, lectures by race pilots and historians. At Cleveland Airport Holiday Inn, (216) 946-9069.

**May 5**

Eta Aquarids meteor shower, two to three hours before sunrise. \*

**May 9**

Armed Forces Day open house and

airshow. Military aircraft exhibits, airborne demonstrations, Air Force Thunderbirds. At Andrews Air Force Base, Camp Springs, MD, (301) 981-3445.

Astronomy Day Open House. Views of the sun through observatory and amateur telescopes, concert by the U.S. Navy Band, and tours of the observatory grounds and the Master Clock facility, which houses the world's most accurate atomic clock. At the U.S. Naval Observatory, Washington, DC, (202) 653-1543.

**May 16 & 17**

Open Cockpit Weekend. Approximately 15 aircraft, including a Boeing B-29, an F4U Corsair, and an F-100 Super Sabre, will be open to visitors. At New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

**May 16-June 14**

"Jupiter and Its Moons," Smithsonian Traveling Exhibition. At the lobby of Two World Trade Center, New York, NY, (212) 466-4233.

Courtesy of Margaret Polk



*Margaret Polk, the original Memphis Belle, meets her B-17 namesake in 1944.*

**May 17**

Memphis Belle Pavilion Grand Opening. Newly restored B-17 *Memphis Belle* moves into new pavilion. B-17 flyby, airshow, crew reunion. At Mud Island Mississippi River Museum, Memphis, TN, (901) 576-7241.

**May 18-20**

American Helicopter Society 43rd Annual

Forum and Technology Display. At Cervantes Convention Center, St. Louis, MO. AHS, (703) 684-6777.

#### May 23

Jackpot Pigeon Race. More than 4,000 birds will be released simultaneously from a mountain near Jackpot, Nevada, in one of the country's largest pigeon races.

Destination: the San Francisco Bay area, 550 miles as the pigeon flies. To date, the fastest bird has averaged 52 mph.

Thousands of dollars are wagered on this annual race, which is sponsored by Bay Cities Racing Pigeon Combine. At Cactus Pete's Casino, (800) 821-1103.

#### May 23-June 21

"Twenty-five Years of Manned Space Flight," Smithsonian Traveling Exhibition. At the Buffalo and Erie County Naval and Servicemen's Park, Buffalo, NY, (716) 847-1773.

#### May 28-31

"Space Exploration: Recent Past and Near Future" and "Twenty-five Years of Manned Space Flight," seminars by National Air and Space Museum curators. At University of Wisconsin, Madison, WI. Smithsonian National Associates, (202) 357-1350.

#### May 30-June 7

New York-Paris Air Rally. This general-aviation aircraft race celebrates the 60th anniversary of Lindbergh's solo crossing of the Atlantic Ocean.

#### June 11-21

Paris International Air Show. At Le Bourget Airport, Paris. International Trade Exhibition in France, New York office, (212) 869-1720.

"Odyssey of Flight" travel package, June 3-15. Includes a two-day tour of the Paris airshow led by National Air and Space Museum curators. Visits to aviation museums in London and Paris are also scheduled. Smithsonian National Associates, (202) 357-4700.

*\*Call the Smithsonian's Earth and Space Report at (202) 357-2000 for recorded information on astronomical events.*

*Organizations wishing to have events published in Calendar should submit them at least three months in advance to Calendar, Air & Space/Smithsonian, Gallery 211 Mezzanine, National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Patricia Trenner

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### The Institution's Institution

Sixty years ago, as Charles Lindbergh flew across the Atlantic in the *Spirit of St. Louis*, a Smithsonian employee named Paul Garber became convinced that the airplane should be in the Smithsonian collection.

Garber, today the National Air and Space Museum's Historian Emeritus, had been so excited by Lindbergh's departure from New York's Roosevelt Field that he wrote a cablegram asking Lindbergh to donate his airplane for exhibit. Garber took it to the Secretary of the Smithsonian, Charles Greeley Abbot, for approval and said, "Dr. Abbot, you may have heard that the *Spirit of St. Louis* took off. I heard it on my radio this morning and Lindbergh's now flying up the coast and, sir, he's gonna make it and, sir, we ought to have that airplane in the collection, sir, because it will be the first American airplane to fly nonstop across the Atlantic and he'll be the first to fly across that ocean solo and he's an airmail pilot and I was in the airmail ground crew and I know how good those airmail pilots are . . .

"As soon as he could interrupt me,"

Garber relates, "Dr. Abbot said, 'Now just a minute, Garber, he hasn't gotten there yet!' I said, 'Yes sir, but he's going to.' Dr. Abbot said, 'We'll see.' His chin went down. His eyes sort of closed and I was sort of nodded toward the door. I left him the cablegram. That was probably one of the first things that Lindbergh saw when he woke up after that 10-hour sleep in the American Embassy in Paris."

For years millions of Smithsonian visitors have seen the object of Garber's cablegram. The *Spirit of St. Louis* was displayed in the Arts and Industries Building from 1928 to 1976, when it was moved to the National Air and Space Museum. The Ryan monoplane has a position of honor in the Milestones of Flight Gallery, only a few feet from the Wright Flyer and the Apollo 11 command module.

Garber's 67-year tenure at the Smithsonian is even longer than that of the *Spirit of St. Louis*. Hired in 1920 for a three-month appointment, his stay has been temporary "only in the sense that all of us

are here temporarily." He remembers the Smithsonian when it was a smaller, simpler place, where "paychecks" (his totaled \$700 a year) were bills and coins in little envelopes and the mail delivery system was "one person, one horse, one wagon."

Paul Garber was introduced to aviation on July 27, 1909, when the nine-year-old watched Orville Wright demonstrate a Flyer for the U.S. Army Signal Corps at Fort Myer, Virginia. Seeing the Wright airplane sparked an interest in flight that has not yet dimmed. Sometime around 1912 Garber made one of his first visits to the Smithsonian's Arts and Industries Building and saw the 1909 Flyer suspended from the ceiling "not much higher above the floor than when it flew over my head on the drill field." A year later he founded the Capital Model Aeroplane Club, and the Smithsonian's small aviation collection became a source of inspiration and information for Garber and his fellow club members. He also had an interest in kites and once received some suggestions and a pat on the head from neighbor Alexander Graham Bell. "That was the equivalent of a bishop's benediction," says Garber.

After serving as a sergeant in the Army during World War I, Garber found work with the fledgling airmail service at the nearby College Park, Maryland airfield as a mechanic, clerk, mail-truck driver, and "chief slave." He also received some flight instruction from the airmail pilots, though he has never had a pilot's license. "When I learned to fly you didn't have to have one," he says.

Garber has always been ambitious, brimming with energy and ideas. His first duties at the Smithsonian included the care and repair of locomotives, automobiles, bicycles, guns, telegraph instruments, and telephones, but he says, "I was always thinking of something aeronautical to do." One self-assigned project was to correct mistaken impressions about the design of the Wright 1909 Military Flyer, which has its elevator in front and propellers in back. "I made a mannequin to put in the pilot's seat so visitors could see which way it flew," Garber recalls. "After I finally had

From model airplanes in 1920, Paul Garber (left) went on to work with real ones.



Collection of Paul Garber



*A man possessed by flight, Garber found his ideal job at the Museum.*

him seated comfortably with his feet on the crossbar, hands on the control levers, and head poised at an alert angle, I took a few minutes for retrospection. I thought, 'Orville sat there and Lieutenant [Frank] Lahm sat here.' I made a few comparisons between the Jenny I had piloted and this Flyer. Then I awoke from my dreaming and decided I should get back to my shop. As I reached out for the bosun's chair that I had rigged to get me up in the airplane, a little child cried out, 'Oh look, Mama, that other dummy's moving!' "

Garber's only prolonged absence from the Smithsonian was five years of Navy service during World War II, when he developed aircraft recognition models for the Bureau of Aeronautics' Division of Special Devices and oversaw the production and use of the target kites he invented for ship-to-air gunnery practice. After the war Garber returned to the newly designated National Air Museum as its first Curator, becoming Head Curator in 1952 as well as Senior Historian in 1958. In 1969 Civil

Service regulations required him to retire, but the next day he returned as a volunteer, and was soon made Historian Emeritus and Ramsey Fellow.

Garber's workday typically begins at 7:30 a.m. and ends at 6 p.m. His telephone rings frequently as colleagues, historians, and journalists seek information and advice. His office in the Museum is walled with awards, honorary degrees, and photos of friends and his "dear wife," Buttons, who died last year. He mourns her loss deeply.

Garber's mark is everywhere in the Museum: the Orville Wright mannequin in the 1903 Wright Flyer wears one of Garber's old suits, and in 1980 the restoration and storage facility in Suitland, Maryland, was named in his honor (In the Museum, December 1986/January 1987). Garber has also been instrumental in acquiring many Museum aircraft, including the U.S. Navy Curtiss NC-4, the Douglas World Cruiser *Chicago*, the Curtiss Racer R3C-2, the Ford Tri-motor, and the Boeing 247-D (which he helped pilot on its trip to

the Museum).

Today Garber says that he can look right through a 747 and see in it the Wright's 1909 "aeroplane." "When I see our aircraft," he says, "they're not just things. They are a treasury of memory."

—Monica Knudsen

## Space Tailors

Imagine what would happen to your best suit if you hung it in your bedroom window for a few years, and you can understand why two spacesuits from the Museum's Milestones of Flight Gallery are now off duty for a makeover.

Since 1976, the suits, which were originally worn by astronauts Ed White and Jim McDivitt on the Gemini 4 mission in 1965, have been worn by mannequins. About five years ago curators discovered that the suits were deteriorating, despite the protection of a plexiglass shield. Lillian Kozloski, a spacesuit expert with the Museum's Space Science and Exploration Department, says the culprit is ultraviolet radiation, a component of plain old sunlight.

After four years of deliberation the Museum decided to have the spacewear's manufacturer, the David C. Clark Company of Worcester, Massachusetts, restore the suits. For a little less than \$6,000, Clark, which made all of the National Aeronautics and Space Administration's Gemini suits, is crafting new fabric outer layers for attachment to the original inner suits. The job will take about three months. The original layers, now stiffened, discolored, and frayed, will go into environmentally controlled storage.

Kozloski also notes another problem: the gold coating on White's helmet visor has completely degraded. The coating process is too complicated to duplicate, so the Museum will probably have to create a replica for the exhibit.


The Museum's extensive collection of spacesuits covers every U.S. manned space flight program except the shuttle, and includes the suits Apollo 11 astronauts Neil Armstrong and Edwin "Buzz" Aldrin wore during the first moonwalks (minus the boots, gloves, and life-support backpacks, which were left on the moon as excess baggage), as well as John Glenn's Mercury suit from the *Friendship 7* flight. Also on display is an early prototype spacesuit, a pressure suit designed for renowned test pilot Wiley Post in the 1930s for high-altitude flying. This suit was the third created by the B.F. Goodrich Company. The first one leaked and never made it past the test chamber, and the second was so tight it had to be cut off Post after a fitting

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session. The suit on display is a two-layer outfit, with long underwear inside, a cloth shell outside, and in between a rubber bag holding pressurized oxygen.

Today's spacesuit is more like a personal spacecraft than an article of clothing. It must provide a carefully regulated environment and resist punctures that would cause its atmosphere to leak away. Suits must also be able to tolerate temperatures that range from plus to minus 250 degrees Fahrenheit on the moon and

NASA



*On the moon, astronauts dress for success in bulky suits with life support systems.*

are even more extreme in open space. They also have to shield against garden-variety solar radiation, though they can't deflect cosmic radiation, and astronauts spending months in space will need special shelter from the occasional radiation storm caused by solar flares.

The first genuine spacesuit the Museum acquired was John Glenn's 22-pound Mercury suit, which could be inflated to atmospheric pressure. Gemini suits weighed a few more pounds than the Mercury ensemble, but had to last through up to 14 days of work in space. They came in two styles: IVA (for intravehicular activity) and EVA (for extravehicular activity). Ed White's suit, worn on the first American spacewalk, cost \$26,000 and has 22 layers; an extra torso protection garment has another 17 layers. The bulky Apollo EVA suits have only 21 layers but weigh a hefty 190 pounds, including

portable life support systems.

Shuttle suits are made to last 10 years and are NASA's first reusable suits, which is why the Museum has no castoffs yet. The shuttle EVA suits (astronauts wear coveralls inside the shuttle) weigh 260 pounds, including life support systems. They have 11 layers, with an outer shell of Gore-Tex blended with Kevlar and Nomex for strength. Unlike earlier suits, shuttle outfits are off-the-rack—only the gloves are custom-fitted.

Before the National Air and Space Museum opened in 1976, its spacesuit collection was scattered around Washington and other museums. Suits and components were packed in boxes or stashed in closets, and some of their materials started to deteriorate while in makeshift storage. In 1978 the Smithsonian Conservation Analytical Laboratory recommended that the Museum store its collection horizontally on shelves in a climate-controlled room. The Museum took this expert advice, and now, plumped with stuffing, the suits not on display rest in regulated peace at the Garber Facility.

—Linda Billings

## Now, Voyager

Following its record nonstop, unrefueled flight around the world last December, the ungainly aircraft *Voyager* has another journey to make: to the National Air and Space Museum. After touching down at Edwards Air Force Base on December 23, pilots Dick Rutan and Jeana Yeager received a telegram from James C. Tyler, the Acting Director of the Museum. "As we all knew from the beginning, the airplane which is the first to fly around the world, nonstop, nonrefueled belongs in the national collection of historic air and spacecraft," the telegram read. "The Smithsonian Institution would be honored to accept *Voyager* if it is offered. Again, congratulations to you both and to [designer] Burt [Rutan] and the rest of your team on this historic achievement."

The *Voyager* team members have made no secret of their desire to see their airplane housed in the same building that has so many famous vehicles, and it came as no surprise that they accepted the Museum's offer. But before *Voyager* arrives at the Museum, it will be transported in a C-5 Galaxy to the Paris Air Show for exhibition in June; it may also spend time on exhibit at the EPCOT Center in Florida before coming to Washington. Dick Rutan, who says *Voyager* will never fly on its own again, compares the airplane's future travels with the goodwill tours Charles



Lindbergh flew in the *Spirit of St. Louis* after his transatlantic flight.

Moving the airplane will not be a major problem—it was designed to be disassembled in case a forced landing had necessitated ground transport. The main difficulty will be finding room for it once it arrives at the Museum. With a wingspan of 111 feet, *Voyager* will be the largest airplane in the building, outstretching the previous record holder, Paul MacCready's *Gossamer Condor*, by 15 feet.

The airplane's size limits the Museum's options. "We thought about putting it where the *Gossamer Condor* is now, but we didn't want to move that," says Don Lopez, the Museum's Deputy Director. "And we considered jamming it in below the DC-3 and above the Federal Express jet. But it doesn't really fit the theme of either gallery." Instead, *Voyager* will hang above the lobby facing Independence Avenue, opposite the Milestones of Flight Gallery. There, visitors can see for themselves the fragile-looking airplane that traveled 25,500 miles without a pit stop.

—Tom Huntington

## Museum Calendar

**April 1–May 6** Lecture Series: "Bubbles, Voids, and Bumps in Time: The New Cosmology." Wednesday nights, 6 p.m. Call Resident Associates Program at (202) 357-3030 for ticket information.

**April 4** Monthly Sky Lecture: "Mountain of the Long Eyes." Thomas Callen, Planetarium Program Resource Manager, NASM. Albert Einstein Planetarium, 9:30 a.m.

**April 15** Exploring Space Lecture: "A Universe of Galaxies." John Huchra, Astronomer, Smithsonian Astrophysical Observatory, and Professor of Astronomy, Harvard University. Albert Einstein Planetarium, 7:30 p.m.

**April 21** Starlight Serenade Concert: U.S. Air Force Chamber Players. Albert Einstein Planetarium, 8 p.m.

**April 21–June 9** Lecture Series: "Spies and Satellites: The Acquisition, Uses, and Limitations of Intelligence." Tuesdays, 6 p.m. Call Resident Associates Program at (202) 357-3030 for ticket information.

**April 23** General Electric Aviation Lecture: "The *Hindenburg* Crash." Captain George Watson. Langley Theater, 7:30–9 p.m.

**April 25** Symposium: "The 300th Anniversary of Newton's *Principia*." Albert Einstein Planetarium, 9 a.m.–12 noon.

**April 25–26** Open House: "Wings and Things." Paul E. Garber Facility, Suitland, Maryland, 10 a.m.–3 p.m.

**April 27** Lecture: "Fast Flight's Fantastic Future." John D. Anderson, Jr. Carmichael Auditorium, 8 p.m. Call the Resident Associates Program at (202) 357-3030 for ticket information.

**April 28** Lecture: "The Daedalus Project: Human Powered Flight." Discovery Theater, 7–8 p.m. For ticket information call the Resident Associates Program at (202) 357-3030.

**May 1–3** National Air and Space Weekend. Call the National Associates Program at (202) 357-4700 for registration information.

**May 2** Monthly Sky Lecture: "The Hubble Space Telescope." Richard Schmidt, Astronomer, Nautical Almanac Office, U.S. Naval Observatory. Albert Einstein Planetarium, 9:30 a.m.

**May 19** Starlight Serenade Concert: U.S. Air Force Chamber Players. Albert Einstein Planetarium, 8 p.m.

**May 20** Exploring Space Lecture: "Born in the Milky Way." Alan Dressler, Astronomer, Mount Wilson. Albert Einstein Planetarium, 7:30 p.m.

**May 21** Charles A. Lindbergh Memorial Lecture: Lt. Gen. Benjamin O. Davis. Langley Theater, 8–9:30 p.m.

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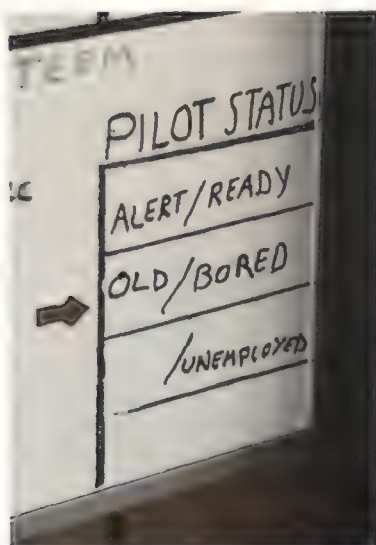
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Aerial fire trucks are usually the first on the scene when California's brush fires rage.

# Fire Bombers

by Michael Tennesen

Photographs by Christopher Springmann



the canyon, feeding on California chaparral—a collective name for the area's tinder-dry scrub and small trees—as though it were gasoline. Once over the blaze, the air attack officer, who will direct the air tankers, radios a quick report to division headquarters while deciding how to slow the fire's progress until ground firefighters arrive.

After hearing the officer's detailed instructions, one tanker pilot checks his aircraft systems, programs the switches that will open his chemical tanks, cinches up his seat harness, and turns toward the blazing canyon. He reads the wind in the fire's smoke, visualizes his exit from the narrow pass, then banks and heads down into the canyon. Near the bottom of his run, the pilot pushes a button. A sudden cloud of pink retardant seems to explode from the airplane's belly. The cloud blossoms, then settles, leaving a brightly colored stripe on the ground. The first line of defense against the inferno has been drawn.

Firefighters and foresters have been experimenting with the use of airplanes against fires since the 1930s. They tried everything from beer kegs filled with water to retardant-filled fuel tanks dropped from B-29 bombers. But the first use of an airplane that could be legitimately described as an air tanker occurred in California's Mendocino National Forest in 1955, when a Stearman biplane, an aircraft usually used for crop dusting, fought a fire by dousing it with

Dust devils propelled by hot, dry Santa Ana winds dance across the runway next to the Ryan Air Attack Base at Hemet, California. In a small room in a low building, a group of pilots listens intently to a message crackling over the radio. Smoke has been spotted in nearby Cajon Pass, a deep, narrow canyon 7,000 feet up in the San Bernardino Mountains.

Then the alarm sounds.

The pilots break for their aircraft. Within minutes, a specially equipped Cessna 337, with a pilot and a California Department of Forestry (CDF) air attack officer aboard, growls down the runway. Two thundering Grumman S-2F air tankers, their 800-gallon tanks filled with chemical fire retardant, follow the Cessna into the sky, and all three aircraft head toward a plume of smoke 28 miles due north of the station.

Forty-foot flames dance up the side of

*Once they hunted submarines, but now converted Grumman S-2Fs find their action fighting forest fires.*

*Time between missions can drag for aerial firefighters (top left), but pilot Jerry Sebastian manages to pass the time (above right). Buzz Blaylock sticks a feather in his cap when he goes flying in his tanker.*





water from onboard tanks.

Later in 1955, while fighting the devastating Inaja fire in San Diego County, firefighters in Stearmans added borate salts to the water. The press, with its penchant for catch phrases, promptly dubbed the airplanes "borate bombers." But borate compounds weren't used for long. They're caustic chemicals that can destroy vegetation and virtually sterilize the soil. Today, aerial firefighters use Monsanto Phoschek D75, a combination of diammonium phosphate—which doubles as fire retardant and fertilizer—chemical stabilizers, and a pink iron oxide dye that marks the drop's location.

Its beginnings may have been modest, but today air attack has grown to include 13 CDF bases in California and 41 U.S. Forest Service tanker bases across the nation. Air tankers are also used in Canada and Europe. And the fleet, which is still largely made up of retired military airplanes with huge retardant tanks installed where bombs and cargo used to go, has given forest-fire fighters a first-strike capability.

In the past, the forest service has employed air tankers that ranged from modifications of the venerable B-17 to the sublime PBY Catalina and the chubby TBM torpedo bomber, all fitted with tanks by the handful of companies in the United States and Canada that can do the job. Today the forest service has moved toward modified DC-4s, -6s, and -7s—all transport airplanes. The CDF likes the S-2F, a rugged, twin-engine, carrier-based airplane that used to perform antisubmarine activities for the U.S. Navy. The aircraft are acquired from the surplus and second-hand markets, then stripped and modified, usually by contractors who bid to provide the service, often complete with pilot and maintenance crew.

The old piston-engine airplanes are not likely to be replaced anytime soon. "They aren't as fast as today's military airplanes, they burn more expensive fuel, and they need a lot of maintenance, but so what?" says Dale Newton, president of Aero Union, a contractor in

Chico, California. "You fly them only 100 to 150 hours a year. It's like a fire truck; there's no sense in getting a new model every year when it sits in the firehouse most of the time."

The airplanes find most of their work in Southern California, where each summer's dry period extends the fire season from June to November, the longest in the nation. Air Operations Officer Don Cockrum says that the Ryan Air Attack Base, which is operated jointly by the CDF and the U.S. Forest Service, "holds the dubious honor of pumping more retardant for wildland fires—1.3 million gallons annually—than any other base in the world."

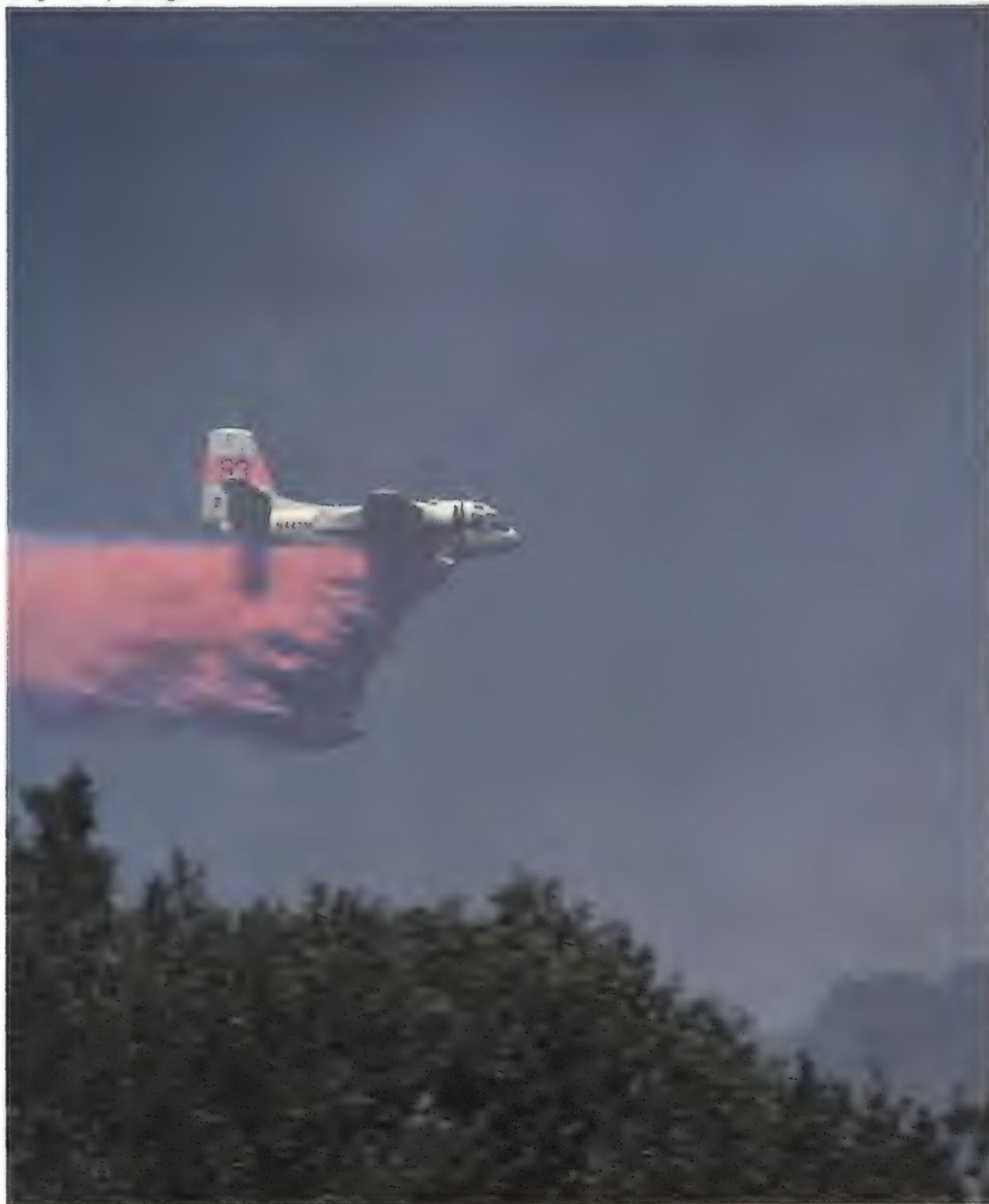
Part of Southern California's fire problem stems from its vegetation. The thick, resinous leaves make the plants

potential firebombs. In fact, both the chaparral and the fires that feed on it are most common in the California foothills at elevations of 1,000 to 5,000 feet. Some biologists believe that the scrub has actually adapted itself to burn and that some of the plants' seeds may need a fire's heat to germinate.

Northern California poses different problems, according to Donald O'Connell. A six-foot, four-inch 53-year-old who has been fighting wildland fires since he was "in reform school and they came around looking for volunteers," O'Connell today is the air operations of-

*A mix of chemicals and dye, fire retardant provides a smothering weapon against woodland blazes.*

Craig Aurness/West Light



*While it's hot going for ground crews, tanker pilots find flying above infernos equally dangerous (left).*



*A salvo from the tanks of this converted Douglas B-26 will fireproof woodlands on the flanks of a fresh fire.*



ficer of the Chico Air Attack Base near Sacramento, where forests blanket the base of the Sierra Nevada. "Here you have timber, a much denser fuel," he says. "It's harder to get retardant to penetrate it because a lot hangs up in the trees. It takes more heat to ignite, but once it goes, it's hotter and harder to stop."

Behind firefighters like O'Connell and Don Cockrum is an elite corps of seasoned pilots (only about 100 nationwide) who hold some of the most enviable jobs in commercial aviation. Averaging 40-odd years of age but sometimes in their 60s, the pilots tend to be well seasoned. And with few pilot positions available and a low turnover, new jobs don't open up that often.

Part of the reason the turnover is so low may be that the pilots like what they do. "It's the smoke," says Jerry Sebastian, a pilot and grandmother who flies the lead airplane at Ryan. "When you're off five or six months and you come back, that first fire really smells good. After a while your clothes begin to smell of it. It's kind of an addiction."

"It's like combat," says Monroe "Buzz" Blaylock, a retired Air Force colonel. Blaylock became a tanker pilot after he received a promotion that would have ended his flying days. Instead of moving up in the Air Force, he moved out. "You're out there with an element of danger fighting the common enemy," he says of his current duties. "And if you can overcome that enemy, there's a psychic income you don't get flying executives back and forth."

The allusions to combat come naturally. Each battle has its general, an "incident commander" who has the final word on overall firefighting strategy and runs his divisions as if they were parts of an army. The warriors are the crews on the ground, working with fire engines and bulldozers. Airplanes and helicopters provide the air support, with an experienced air attack officer coordinating the tanker pilots to ensure the safety of the crews on the ground.

On bad days in California, wildland fires can sprint like jack rabbits. "People can't lay hose that fast. Hand crews can't cut fireline that fast. Bulldozers can't climb hills that fast," says Don Cockrum. "The air attack team tries to retard the advance of the fire so that

ground forces can get in there and support the line."

Seen from the sky, a wildland fire grows like an expanding balloon. It is anchored at the point of origin and expands as it burns, its rounded "head" steered by the wind. Standard firefighting tactics first concentrate on a fire's flanks, so the air attack officer is least likely to call for a drop directly on the head—"headhunting"—too early in the battle. "You might put out a small fire that way," says firefighter Frank "Smokey" Vallesillo, the amiable forest service air attack supervisor at Hemet. "But once the fire's grown to more than five or six acres, you run the risk of splitting the head. Then you've got two fires to worry about."

Almost all of California's forest fires

pilot himself, the air attack officer gives his full attention to the fire and the situation on the ground. He is a veteran firefighter who has learned his job from the ground up. Working under the overall command of the incident commander, he is also the ground troops' eyes. From his perch, he reports to the commander on the fire's state and helps to guide vehicles along back roads to the fire site. He first singles out starting fires, attempting to stop them with retardant before they become ferocious. He is linked to the tankers and to the ground by a stack of radios in the back of the Cessna.

In the days before radio communication, the pilots would simply fly to a fire, pick a spot, and drop their load. "It was pretty much a rodeo," says Harry



are contained within the first 10 acres. The exceptions, however, can be catastrophic. "When a fire gets into its second or third day," says Cockrum, "everyone's tactics change. We try to herd the fire—turn it away from structures or turn it into a natural border—more than put it out."

The air attack officer normally sits in the right front seat of the lead airplane—the Cessna 337 Skymaster is the current favorite—as it flies over the fire for a four-hour shift, checking out the winds, the terrain, and the location of the ground crews. Not necessarily a

Chaffee, one of the first tanker pilots and now chief mechanic for Hemet Valley Flying Service. "It's different now. We've got the latest in radio and navigation equipment. You just feed the coordinates of the fire to the loran navigation system, and it will tell you which way to steer."

Modern aerial communications were essential during the Wheeler Canyon fire, which an arsonist ignited about 100 miles north of Los Angeles in July 1985. In one day the blaze consumed 20,000 acres, and the fireline quickly stretched to 120 miles. "We had to monitor five



*The first firefighting S-2F, at left, rests in a yard. Parts from "retirees" keep successors flying (above).*

*Preflight inspections are important: tanker duty is as hard on the aircraft as it is on the pilots (opposite).*

*Pilot Rich Ruggiero checks the guts of his S-2F. Chemical retardant is corrosive and can eat away metal.*

radio frequencies," says Smokey Vallesillo, "and the fire was so big that radio reception between groups on the ground was bad, so we had to relay messages back and forth. And the news media was all over, too. There was so much radio chatter your ears would still be buzzing even after you'd quit work." Air tankers fought the Wheeler fire for two weeks, dropping 800,000 gallons of retardant. Before it finally died, the fire consumed 118,000 acres.

Though the air attack officer makes the tactical decisions, it's up to the tanker pilots to deliver the payload. Forest service pilots usually follow a lead airplane, but CDF tanker pilots make their runs solo. "The CDF feels their air tankers know the area better," says Captain Bill Mason of the Ryan base, "whereas the U.S. guys could be doing Idaho one day and California the next."

Guided or not, piloting a tanker is a dangerous job. The combination of steep mountains and burning timber creates terrible air turbulence. "There's a lot of bad air around a fire," says O'Connell. "There's a lot of bumpy air around mountains even without a fire." Chico tanker pilot Gene Simpson agrees. "It's always bumpy and it's always smoky. Currents are bad. Turbulence is bad. It's just *always* bad and that's all there is to it. You just make the best of what you've got."

The severest fire-created phenomenon is the firestorm, a whirling column of supercharged air created by the updrafts that boil out of the flames. "It looks just like a building thunderstorm," says Buzz Blaylock. He remembers a firestorm caused by a 1980 fire in the El Dorado National Forest near Lake Tahoe. "You could see limbs and brush uprooted and carried right up into the convection column," he says. "The stuff was thrown out the side and would float back down to earth still burning. And you'd hit those with the airplane. The convection column looked just like an atomic cloud."

Although Federal Aviation Administration regulations prohibit tankers from flying below 150 feet, the pilots like it best down low. "You get me above 2,000 feet and I'm lost," says 15-year veteran firefighter Mort Gossatt. Others say low altitudes are necessary for effective use of the retardant. "If

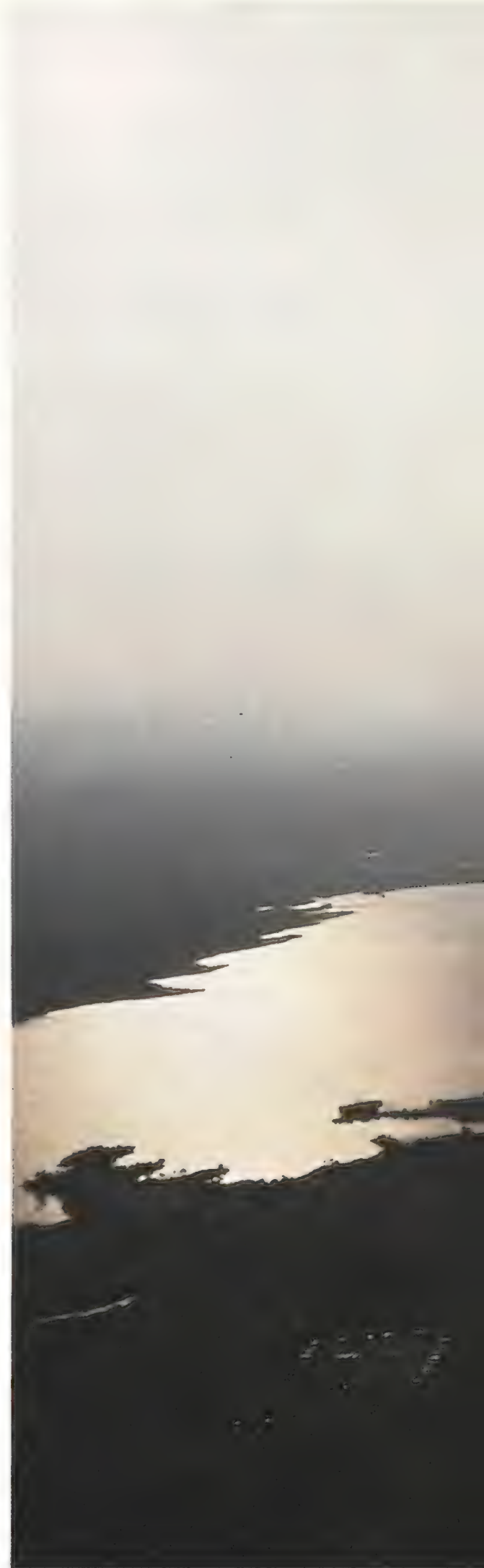
you're too high it's just going to blow away," says one pilot. "It won't do any good at all."

But when dropped from too low an altitude, the retardant may not disperse sufficiently before hitting the ground, and the impact can only be compared to that of an artillery shell. "The mass is such that if you go too low it can completely destroy a fire truck," says Blaylock.

Other dangers lurk at low altitudes, including power lines and antenna towers. Dead trees are a serious hazard. "They call 'em widow makers," says Gossatt. "They're hard to see because they're dead and don't have any foliage on them."

But the worst hazard a pilot faces is lack of visibility. Blaylock was fighting a fire near Eureka in Northern California in 1981 when he saw a DC-6 hit a tree obscured by smoke. A large branch broke through the windshield and lodged in the radio rack behind the pilot. Despite the damage, the pilot got his airplane back to base.

A pilot at another Northern California fire, this one near Columbia that same year, wasn't so lucky. "He was making his drop when a minor flareup obscured the drop area with smoke," says Blaylock. "He shouldn't have continued, but he did. He hit a 40-foot-high tree and then another and then hit the



*A brimming reservoir beneath two S-2Fs belies the dry season that turns California into a carpet of tinder.*

*Air Attack Officer Donald O'Connell (left) and tanker pilot Gene Simpson relive the battle after landing.*



ground." The pilot was killed.

According to Donald O'Connell, air attack averages about one casualty per year. "They don't usually survive a tanker crash because they're so close to the ground," he says. Pilots generally avoid unnecessary risks, but there are

exceptions. "If there's somebody on the ground hurting—a 'dozer operator who's really hot or a hand crew that really needs a drop—you'll hang it out a little bit more," says Blaylock.

Despite the risks—or perhaps because of them—tanker pilots love their

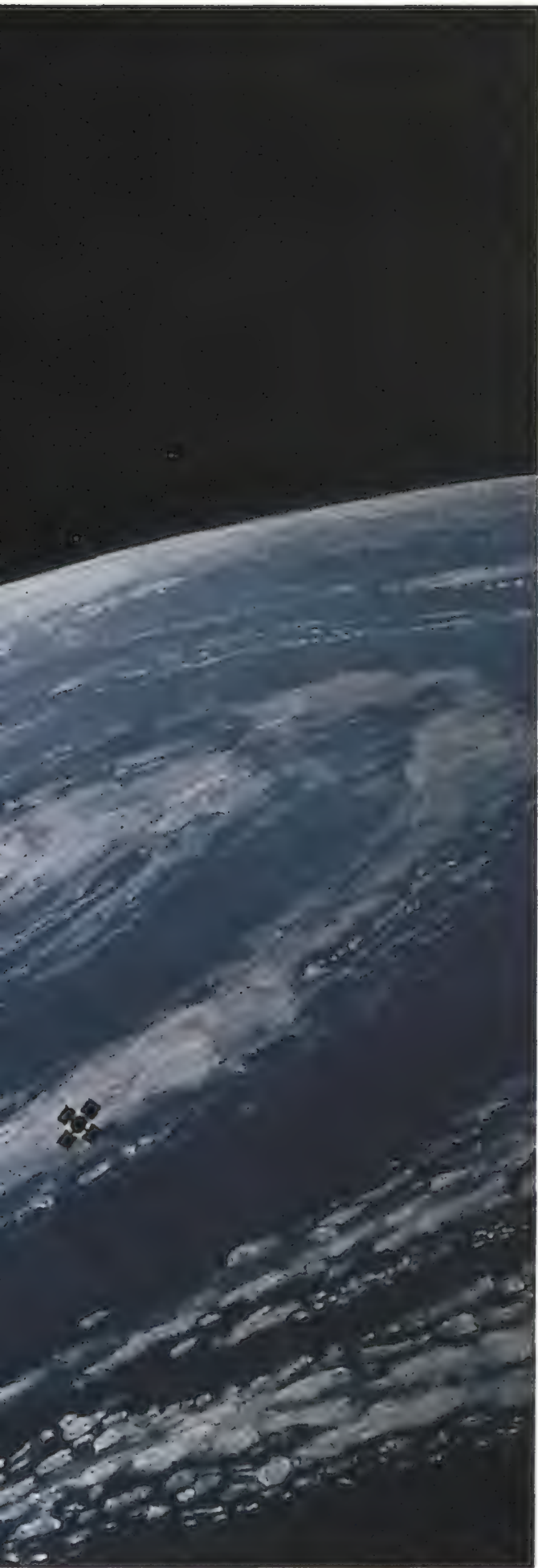
job. And when O'Connell, an experienced pilot, retires from the CDF next year, he won't be taking it easy: he plans to go back to work as a tanker pilot for a contractor. "I've been directing them for a lot of years," he says. "Now I'd like to go fly one." —



# Eyes on the Sky

by James E. Oberg

One of the unearthly tasks French spacefarer Jean-Loup Chrétien performed during his week-long stay on the Soviet space station *Salyut 7* in 1982 was launching his own satellite. The "spationaut," as France's spacemen had dubbed themselves, and four Soviet cosmonauts had crammed a bag full of dirty clothes, food wrappers, and other trash and prepared to commit littering on a cosmic scale. They stuffed the medicine-ball-sized package into a trash disposal airlock, closed the hatch,



William Hartmann

*An exploding spacecraft adds a spray of debris to an Earth orbit that has become increasingly cluttered.*

and rotated the airlock chamber to face outward. Chrétien had the honor of pulling the lever that opened it, and air pressure popped the bag into space. The five voyagers cheered the launching of a new satellite.

The cheering had hardly died down before the satellite drew the attention of

## Whether it's a satellite or a piece of orbiting trash, the U.S. Space Command keeps tabs on it.

an Earthbound crew stationed far underground in the Rocky Mountains. At the Cheyenne Mountain complex of the North American Aerospace Defense Command (NORAD) in Colorado, orbital analysts soon noted the presence of a small body in the neighborhood of *Salut 7*. "There goes another garbage can," joked a U.S. Air Force officer. "Let's give it an object number."

For the remaining weeks of its life, until it fell out of orbit, hit the upper atmosphere, and flashed through an incandescent finale, the garbage bag remained in the NORAD space surveillance center's computerized satellite catalog database, identified by object number and orbital characteristics. For the record, the garbage can was cataloged as 1982-033L, object number 13332. It burned up on August 11, 1982, after 40 days in space and more than 600 orbits of Earth. Cheyenne Mountain's analysts kept track of it every inch of the way, feeding data into computers that monitored its position.

The public image of the space surveillance center—run by the U.S. Space Command (U.S. SPACECOM) since September 1986—is one of row upon row of computer screens crisscrossed with satellite paths and surrounded by complicated control panels. Though the Cheyenne Mountain complex (which is managed by the Air Force Space Command) has such specialized facilities for surveillance operations, support staff spend most of their working hours at standard government-issue metal desks. Their offices just happen to be deep inside a granite mountain.

The Cheyenne Mountain complex has inspired set designers for numerous Hollywood movies. *WarGames* has a scaled-down version, from blast-proof door to cavernous workspaces. (The movie version of Cheyenne Mountain's NORAD command post is bigger than life, however.) In reality, the facility's

underground water reservoirs and the Air Force's "underground navy"—a maintenance vessel—provide a touch of the bizarre. For space surveillance center crews, the long subterranean trip from outdoor parking lot to workstation may be the strangest part of their day. Boulder-catching nets stapled to rock walls and roofs are one reminder that the facility is designed to survive a nuclear attack. From this odd spot, space surveillance specialists project their senses deep into space.

Despite frequent analogies to air traffic control centers, where experts huddle over radar screens aglow with myriad labeled blips, U.S. SPACECOM uses tracking techniques that are unique to space. Each object that has been cataloged—more than 17,000 so far, of which more than 6,000 are still in orbit—is registered by orbital characteristics: inclination, the angle at which an orbit is tipped relative to the Earth's equator; period, the time it takes an object to complete an orbit of Earth; and apogee and perigee, the points of an orbit farthest from and closest to Earth, respectively. U.S. SPACECOM can predict a satellite's past, present, and future positions using these and other orbital characteristics. To determine a satellite's position at a specific time, computers start with the set of orbital elements already recorded—shape of orbit, for example—add a predicted time of atmospheric reentry, factor in the laws of orbital mechanics, and come up with an answer.

Computers at the center are constantly calculating where satellites are, whether for observation passes, communication sessions, or collision avoidance checks. Continuous tracking of the metallic denizens of space is physically impossible; U.S. SPACECOM's sensors lock onto objects only when they're within view. Satellites in low Earth orbit, for example, can cross the sky from



*Without the military's network of far-flung radars, tracking space objects would be much harder.*

*Cheyenne Mountain's big board is like a telethon for trackers: it maintains round-the-clock watch on orbits.*

Eric Meola





ellites, orbital analysts prepare to make radar trackings to determine the orbit of the payload. When the new object is registered, it receives an object number and an international designator consisting of the year of launch, place in that year's sequence, and letter code indicating what type of object it is: *A* objects are payloads, *B*s are booster stages, *C*s, *D*s, and so forth can be assigned to debris such as protective payload shrouds or window covers. If more than one payload appears, the additional objects also receive letter designations. Sometimes a satellite or its booster stage explodes, and each shard that is big enough to be detected is assigned its own number.

Many different kinds of radar feed data to the surveillance center. Some of them, specially designed for space tracking, are found on the islands of Kwajalein, Ascension, and Antigua, as well as throughout the United States. An old but serviceable system run by the U.S. Navy and used by the surveillance center encompasses a series of radars running across the continental United States; this "fence" detects all objects passing above it. At Shemya Air

Force Base in the Aleutian Islands, the Cobra Dane radar monitors Soviet missile tests and also registers passing satellites. Another radar installed near the Soviet border in Turkey performs the same dual job. Three giant ballistic missile early-warning-system radars in Alaska, Greenland, and England watch for Soviet missiles but also feed satellite data to Cheyenne Mountain.

If an object is within several hundred miles of Earth, U.S. SPACECOM's worldwide sensor network can detect quite a bit more than its mere presence. Fluctuations in brightness indicate that the target is rotating. Surveillance crews can estimate the shape of a target based on variations in radar echo strength. Through powerful optical telescopes, fuzzy outlines of objects can often be discerned. And on occasion, powerful viewing systems placed in orbit to keep an eye on Earthbound activities can reportedly be turned around to catch high-quality glimpses of passing objects worthy of note.

But while U.S. SPACECOM's radar network does a good job of watching everything from a screwdriver dropped by an astronaut to a 40-ton Soviet space

station retired from service, the radar can only cover orbits within a few thousand miles of Earth. An array of telescopic cameras keeps watch at altitudes of up to 24,000 miles, but the size and reflectivity of an object affect the chances of its being seen by the cameras. Outside these bounds, U.S. SPACECOM's sensors are useless, but there's plenty to see. The Soviet *Prognoz* and *Astron* scientific satellites follow a path swinging within a few hundred miles of Earth over the Southern Hemisphere, where SPACECOM has few sensors, then looping more than a 100,000 miles away from the planet over the Northern Hemisphere. "We never see them," one orbital analyst remarks. "We just have to trust the orbital data the Soviets provide."

Deciphering new blips on the radar screen can be tricky. Sometimes, advance notice of what's aboard a rocket about to go up can throw analysts off. One example occurred in August 1986, when Japan launched its first liquid-hydrogen-fueled rocket into orbit. When the H-1 rocket blasted off from Tanegashima Space Center, the space surveillance center knew it was carrying two test satellites. One was a scientific satellite, the other a small amateur radio satellite called *Oscar 12*. The launch went flawlessly, and within a few days NORAD (which was running the surveillance center at the time) issued orbital predictions for the two satellites and the booster stage that placed them in orbit. But amateur radio operators had problems with the data. *Oscar 12* had a radio transmitter on board, so the hams knew exactly when it was passing over their stations. NORAD's orbit predictions deviated from reality by several minutes, and the gap was broadening.

Before *Oscar 12*'s first week of life was over, NORAD had figured out—mainly by heeding complaints from ham operators—that it had not been tracking *Oscar 12* at all. The object thought

*Had cosmonaut Svetlana Savitskaya dropped a wrench, Earth would have gained a new satellite (left).*

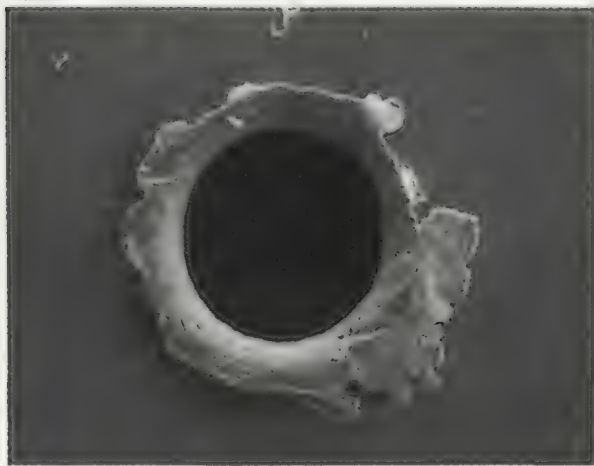
*Spacesuits provide scant protection from minute debris orbiting the Earth at several miles per second.*

SOVFOTO





NASA



*When a spaceborne paint chip tore a half-inch hole in the insulation of the satellite Solar Max...*

to be *Oscar 12* was actually a piece of debris that had broken off the H-1 booster stage. *Oscar 12* was so small and so close to the H-1's other satellite that radar had not distinguished between the two. Once NORAD figured out its error, a radar search was initiated and the real *Oscar 12* was pinpointed and properly cataloged (see "Homemade Satellites," December 1986/January 1987).

After being located and cataloged, space objects are identified. Flight plans and payload information are generally available for most launches outside the Soviet Union. The vast majority of Soviet-launched satellites follow orbits that only the Soviets use. This makes identification simple. U.S. SPACECOM won't confirm it, but it's believed that Cheyenne Mountain's orbital analysts know that a Soviet satellite orbiting at an altitude of up to 280 miles with an orbital inclination of 70.3 degrees is a photographic reconnaissance satellite launched from Tyuratam. If the inclination is 82.3 degrees, it's the same type of satellite but it's been launched from Plesetsk. If it's orbiting at 620 miles and inclined at 82.9 degrees, it's a navigation satellite launched from Plesetsk.

Identifying Soviet spacecraft has become fairly routine, but the Soviets conduct a truly weird space shot every once in a while, departing from old patterns and sending orbital analysts scurrying. The story of one Soviet oddity started this way: On June 21, 1985, a rocket blasted off from Tyuratam, and NORAD analysts determined that it had launched three objects with unfamiliar

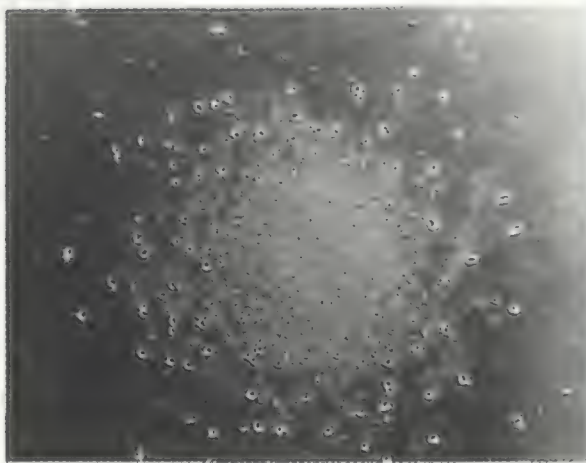
orbital characteristics. NORAD ultimately decided the objects were small enough to be cataloged as debris, and all three burned up within a week or so. But NORAD had not found a payload or booster stage—so where did the debris come from?

The Soviets heightened the mystery by making no mention of the launch—it was their first secret launch since 1966. Thirteen months later, the Soviets announced the launching of a satellite into an orbit similar to that of the three long-gone mystery objects. The new satellite was accompanied by four pieces of debris that had been set into orbit at the end of the launch. Civilian observers identified the new satellite as a test payload carried by a new kind of Soviet rocket, and they finally concluded that the mystery objects of 1985 were debris from a failed launch of the new rocket, explaining the similar orbit and absence of payload and booster stage.

Even with the highest of high technology at its beck and call, U.S.

*... the remains splattered on the coating beneath the craft's outer blanket.*

NASA



SPACECOM still can't pick out all of the objects it considers important enough to track. These elusive objects are debris too small for radar detection and too dim for SPACECOM's cameras. Clouds of tiny debris orbit Earth, and estimating their number and distribution is tricky. The thickest belt of debris is thought to be orbiting at an altitude of 400 to 600 miles, where a large part of the satellite population resides.

Astronauts who repaired the National Aeronautics and Space Administration's Solar Maximum satellite in 1984

Teledyne-Brown for NASA

*The swarm of objects surrounding Earth has become even denser since a computer made this image last year.*



brought back evidence of the damage debris can cause—a piece of Solar Max's protective blanketing that was pitted with tiny craters made by natural and manmade debris. During an earlier shuttle mission, a piece of manmade debris traveling at two to four miles per second hit the orbiter, digging a small but noticeable pit in a window. Thermal protection tiles from orbiters flown on other missions show evidence of high-speed collisions with tiny shards of manmade debris. And it's not just spacecraft that run a risk of bumping into space junk. If an astronaut's suit is torn by even the tiniest piece of debris, the damage could be deadly.

"The real danger to spacecraft comes from centimeter- to millimeter-sized objects," notes orbital debris specialist Don Kessler of NASA's Johnson Space Center. "Objects smaller than a millimeter across, such as those we saw traces of on the thermal blanket recovered from Solar Max, might thoroughly damage a shuttle window or, at worst, might even penetrate a space suit."

In an attempt to observe centimeter-sized objects in orbit, a team from the Massachusetts Institute of Technology's Lincoln Laboratory under contract to Johnson Space Center spent nine hours at the Lincoln Lab's 31-inch telescope near Socorro, New Mexico. Just after sunset, the team pointed the telescope straight up and watched. "If the MIT people had seen only cataloged objects," Kessler reports, "they'd have observed maybe one blip per hour. But even after eliminating spurious blips such as meteors, they recorded five times as many objects as NORAD had on the roster."

Where did all this stuff come from? Eighty objects have been observed to disintegrate in orbit over the past three decades, with the leading cause thought to be explosions caused by leftover fuel or other volatile materials. Another possible cause is collision with debris. "There is a 50-50 chance that one of those 80 breakups was caused by a collision," Kessler says. "And the likeliest candidate is *Kosmos 1275*," a Soviet spy satellite launched in May 1981, even though "there was no known reason for that satellite to disintegrate. It had no fuel or explosives aboard and was not one of the known types that do occasion-

ally explode."

U.S. SPACECOM's space surveillance center detects, tracks, identifies, and maintains the status of manmade objects in space. Period. But Kessler and other analysts outside Cheyenne Mountain use U.S. SPACECOM's data to reconstruct events such as explosions in space. In theory, Kessler says, a debris cloud created by an explosion is not quite the same as one created by a collision, but unfortunately most of the difference involves particles smaller than four inches wide, and SPACECOM has

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**Space trackers have observed 80 breakups in space, and they say at least one resulted from a collision between a satellite and a piece of debris. Someday there will be so much orbiting debris that chain collisions will be inevitable.**

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nothing handy that can detect space dust this small. A satellite explosion generates only a few thousand millimeter-sized particles, while a collision produces tens of millions, he explains. Further, a collision should eject smaller fragments more forcefully than larger ones. Kessler and other observers applied these rules to orbital data from Cheyenne Mountain on 200 objects reported to be associated with *Kosmos 1275* and concluded that the satellite had in fact shattered in space, leaving a trail of thousands of uncataloged bits and pieces along with the official registered objects.

At some point, Kessler warns, collisions will become so frequent that the resultant debris will set off a chain reaction of additional crackups. "We're not there yet," he admits, "but with any normal growth in launchings over the

next 10 or 20 years, we should expect to see more and more collisions."

Space observers such as Kessler do what they do because they're curious. U.S. SPACECOM collects information; it does not, officially, speculate on its meaning. And some amateur space trackers don't like waiting for U.S. SPACECOM to release its data. In 1983, the Air Force established a policy of withholding information on the orbital paths of U.S. military satellites until the information was filed in a monthly space object registration report to the United Nations. These reports include data on all objects, United States and foreign, cataloged by U.S. SPACECOM's surveillance center in a given month. A U.S. SPACECOM spokesman says the reports are filed regularly for the preceding month; amateur trackers say it takes longer. U.S. SPACECOM has made it harder for them to obtain orbital data promptly, they claim, because some amateurs—specifically, members of the British Interplanetary Society—had been publishing distressingly accurate reports on U.S. military satellite missions based on hitherto-unclassified data from the Cheyenne Mountain space surveillance center.

Some members of Earth's exclusive spacefarers' club have already learned the value of accurate orbital data on nearby objects. In 1978, two cosmonauts in the then-brand-new *Salyut 6* space station inaugurated a marvelous new feature, a trash disposal airlock. A few hours later, mission controllers directed the cosmonauts to look out the window, since the Soviet equivalent of NORAD was tracking some "unidentified flying objects" near the station. One of the cosmonauts recalled how he felt when he spotted two dark round objects in pace with the station out near the horizon. "The hairs on the back of my neck stood up," he wrote, and a jolt of fear ran through him. Then the cosmonaut realized that what he saw were the trash bags he and his comrade had just dumped into space, circling back past them because of an improper ejection direction.

As the cosmonauts had a good laugh over their UFO scare, computers at Cheyenne Mountain were humorlessly considering the newly charted orbits of objects 1977-97E and -F. ➤

*You don't  
have to be an  
Einstein to get  
involved in  
National  
Science and  
Technology  
Week—April 5-11,  
1987*

Join museums, schools, corporations and universities across the country in a week of activities designed to stimulate interest in science and technology. The week's events and programs include:

- A launch of 200,000 balloons at the beginning of the week, with weather cards to be returned by the finder. To take part, contact: *Triangle Coalition*,

*attn. Dr. Livermore, National  
Science Teachers Association,  
1742 Connecticut Ave., N.W.,  
Washington, D.C. 20009.*

- A traveling exhibit on biological diversity, produced by the National Science Foundation and the Smithsonian Institution. For information, write:

Smithsonian Institution, SITES,  
Washington, D.C. 20560.

- Educational activity packets that will help students explore scientific concepts. These will be sent to elementary and middle/junior high schools in every state.

### Other Ways to Participate

Students can assume the character of a famous scientist or engineer, and recreate, or even anticipate, a great moment in science. They could also produce a science-related video or radio broadcast, or a special newspaper with scientific games, puzzles and stories. Members of more advanced classes can work with younger students, and teachers can introduce a topic, such as camouflage in nature, and challenge the class to create camouflage designs for various backgrounds. *Whatever you do. . . get involved.*



*The National Science Foundation (NSF) is a federal agency that provides financial support for research and education in science, mathematics and engineering. For the past three years, NSF and several corporations have sponsored National Science & Technology Week, working as a clearinghouse for activities throughout the United States.*





Redwoods, Bull Creek Flat, Northern California. Photograph by Ansel Adams. Courtesy of The Trustees of The Ansel Adams Publishing Rights Trust. All Rights Reserved.

Like the  
California  
Redwoods,  
NASA's  
Space Shuttle  
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# Trial by Flying

Legal tangles and high insurance costs are both symptoms of a chronic illness besetting aircraft manufacturing. But the cure is within reach.

by F. Lee Bailey

The pilot of an Enstrom F-28C helicopter had landed at a motel parking lot to wait out some low clouds. Before the clouds lifted, he flew up about a hundred feet to make radio contact with a control tower. He entered a cloud, became disoriented, and crashed. He was unhurt, but the Enstrom was a mess. The engine was removed and tested, and it ran just fine, but the pilot claimed engine failure. A jury awarded him a new helicopter at the engine manufacturer's expense.

A young doctor had trained for emergency landings more thoroughly than most pilots, so when the tail rotor of his Enstrom helicopter suddenly flew off, he responded swiftly and professionally. He made a successful emergency landing, but then his wife jumped out and ran into a moving main rotor blade. She suffered serious brain damage.

An inspection of the recovered tail rotor revealed that its bearings had been installed backwards. The aircraft had been cared for by a 19-year-old mechanic who had never been trained at the factory maintenance school. The claims were sorted out this way: The mechanic was absolved. The jury felt he was too young to be penalized for his mistake. The injured woman was given about \$2 million of Enstrom's money because the jury determined the company was at fault. The owner's claim for damage to the aircraft was rejected because the jury determined the company was *not* at fault. The judge pointed out that the last two verdicts were clearly inconsistent and that, under the law, Enstrom was entitled to a new trial. He also pointed out that eight jurors had forcefully discussed assessing punitive damages against Enstrom. Enstrom's insurer paid the verdict in favor of the woman.

I owned the Enstrom Helicopter Company when both accidents occurred, and I gnashed my teeth at the thought that Enstrom had to pay for something it couldn't possibly have prevented. On the other hand, I am also a lawyer who has represented victims in countless aircraft accident cases. With the benefit of this dual insight, I have formulated a few thoughts about how redress in such cases may be reasonably and equitably accomplished.

If the manufacturer had built a defective engine, or if the factory had installed a defective tail rotor, most would agree

that the verdicts were justified. Victims of negligence should not be left with a paltry or meaningless remedy. But if the system is grinding out crippling and errant judgments, then it needs an overhaul. And "the system" encompasses not only courts and lawyers but the precepts under which insurance companies do business.

If the effectiveness of our current system is measured by the part of each insurance premium dollar that is ultimately paid to the proper claimants, then it is almost worthless. The conflicting objectives of opposing attorneys drive costs up, clog the courts, and delay payment. Typically, four years pass between an accident and a courtroom result, with another year or two for appeals.

Our hallowed jury system also needs a courageous reappraisal. In cases such as aircraft accidents, a jury trial is often the wrong way to settle disputes. Most other countries that share our system of jurisprudence use juries only for criminal and libel cases. When the U.S. government is a defendant, it will not allow a jury trial. And as technology becomes more complex, the ability of a lay jury to sort out the testimony of "experts" is increasingly strained.

In order to understand the situation, let's look at a reasonably typical aviation accident. A chartered jet strikes a mountain, killing both pilots and four passengers. The charter company is liable, but it has only \$1 million of insurance. Each victim's estate hires a lawyer on a contingency contract, which means that the lawyer's fee will be 33 percent of the recovered amount if the case is settled without suit, 40 percent if it goes to court, and 50 percent if either side appeals. High fees? Maybe. But if the case is lost, the lawyers get nothing after years of work and out-of-pocket costs.

Each plaintiff's lawyer claims more than the value of the policy, so the insurance carrier waits for the court to say who gets how much. The charter company has few assets, so the lawyers cast about for a defendant with deeper pockets. Legal principle says that the plaintiff can recover all damages from any defendant with a large enough bank account or insurance policy. So even if the jet's manufacturer was found to have contributed only 10 percent to the accident through negli-

gence in design, it could get stuck for 100 percent of the award. That practice was recently deplored by an American Bar Association commission, but it continues.

The manufacturer, the charter company, and the estates of the pilots are sued. If it carried insurance, the mountain itself would undoubtedly be hauled into court. The insurance carriers each hire a defense firm, which is generally paid by the day or the hour for each lawyer working the case. The largest fees accrue when the case drags on for years. We now have the makings of a raging conflict.

The plaintiffs and their lawyers want their money now. The defense firms take little comfort in a quick settlement—only a few hours' time can be billed. To compound matters, the insurer may be low on reserves and wish to postpone payment until increased premiums can cover the costs.

It takes four years for the case to come to trial. The charter company's insurer offers its full \$1 million in exchange for a release from further payment. The plaintiffs' lawyers say no—the million will be there by and by. They produce an expert who says that the cockpit layout in the jet was defective, that it

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## When the system costs more than it delivers to intended beneficiaries, something is wrong.

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overtaxed the pilots. The manufacturer produces experts who enumerate the hours of night instrument operations the model has flown in perfect safety.

The defense lawyers meet with the top executives of the insurance companies. There are indications the jury will render a stern verdict, they advise. The executives are all ears: they don't want the blame for a bad result at trial. The manufacturer's insurer ponies up \$2.2 million, the charter company's throws in its \$1 million, and after the plaintiffs agree to settle, each gets \$800,000 minus costs and minus 40 percent for attorneys' fees. The defense firm for the manufacturer bills its client \$450,000; the charter company's lawyers get \$140,000. Various administrative costs for both defendants and plaintiffs are about the same and total \$80,000.

The litigation costs roughly \$3.79 million. Each plaintiff's estate nets \$470,000—a total recovery of \$1.88 million. But to get that money into their hands costs \$1.91 million. When the cost of operating a system is higher than the amount the system delivers to its intended beneficiaries, something is wrong. (Oh, incidentally, the jury feels the manufacturer was not at fault and is appalled by the settlement.)

Because the system is inefficient, the price of aviation insurance premiums has risen. The owner of an aircraft carries two kinds of insurance: liability, covering damage to others, and hull, covering damage to the aircraft. Last year, it cost \$15,000 for liability and hull coverage for my \$50,000 Enstrom helicopter—30 percent of its total value. At 200 flying hours per year, about average for personal use, insurance cost \$75 per hour. All other hourly operating costs were only \$55. I think we can do better.

I no longer own the Enstrom company, but when I bought it

in 1971, a new helicopter cost \$45,000. Hull insurance was running at 15 percent of retail. Buyers did not object much to paying \$500 a month for the helicopter, but they bridled at \$562.50 a month for hull insurance. We had trouble finding buyers. So we set up a program with Lloyd's of London. It had four main points: litigation and lawyers were eliminated; pilots were required to undergo rigorous annual factory flight checks; inspections of the aircraft were required every 100 hours by factory-trained mechanics; and any profits dealers and factory-authorized repair stations realized on parts and replacement helicopters were shunted to the insurer.

Under our plan, if you had a minor accident, a dealer made repairs and was paid for his labor. The factory provided the parts and billed the insurer 75 percent of list price. If the accident were major, you trucked the wreckage to the factory. We rebuilt the helicopter and billed the insurer for labor at our shop rate and for parts at discount. If it was totaled, we sold the insurer a new one at 75 percent of list price. By using this plan, we brought the hull rate down to 6 percent the first year and 4.5 percent the second. Buyers accepted a hull cost of \$168 per month, and sales jumped. Had we been able to address the price of liability coverage with equal success, we'd have sold even more Enstroms.

But some reduction in liability premium costs certainly would have been attainable. Our hull policy's terms provide a simple inspirational model: you were insured if you met the requirements. Liability carriers ought to impose rigid flight checks as a condition of insurance, with limitations to match the pilot's flight experience and proficiency. If a pilot is nabbed in a rule violation, his coverage should be canceled or his rate sharply increased. Limitations on flying in high winds, short fields, mountainous terrain, and other dangerous environments should be imposed. Recurrent training is a must, especially for those who fly only occasionally. For new instrument pilots, or those without experience in a particular model, criteria for bad-weather flying should be stiffer. In order to be insured for adverse flight conditions, a pilot ought to be current and demonstrate a high degree of proficiency. Sloppy maintenance ought to be a basis for disclaiming coverage.

When accidents do occur, we need to avoid the courthouse whenever we can. Liability policies ought to provide for a willingness to submit to arbitration, with an invitation to a plaintiff to agree. If liability is admitted or a percentage of liability is agreed upon, lawyers on both sides should consider that in setting fees. If only damages were adjudicated, the risk to the plaintiff's counsel of working several years for nothing would be eliminated. Except when a longer period of time is required to evaluate the degree of recovery, the case should be disposed of within one year. In serious cases, a *pro tanto* or preliminary payment—including all medical bills—ought to be made to the plaintiff, with the balance to be decided later.

These changes are not radical, and each has already been tested in some form. Insurers are free to tailor their policies with restrictions and conditions. All lawyers welcome handsome fees, but most will work for reasonable ones.

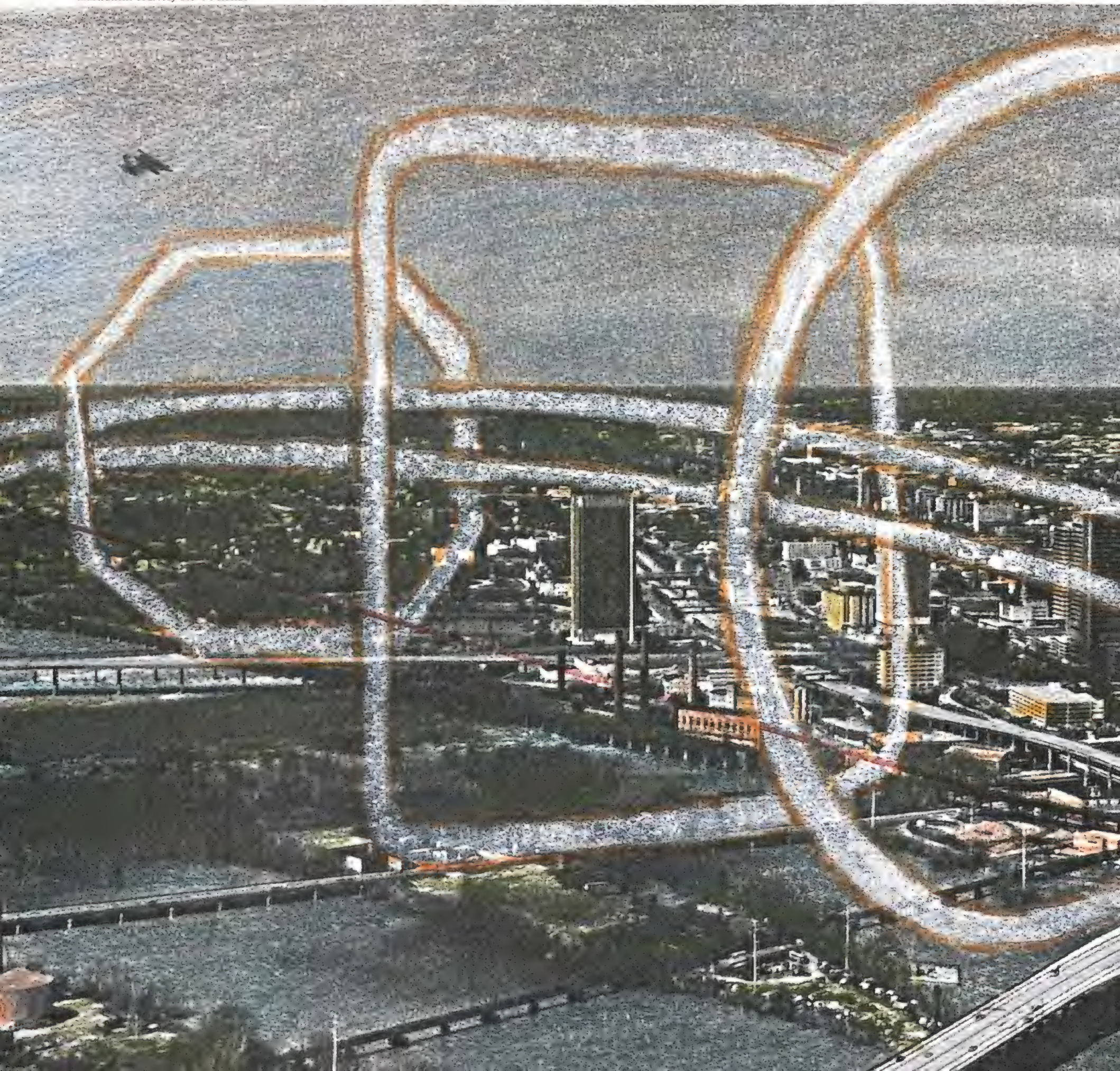
We need a permanent fix for the system because it is not working. The situation is too much like Mark Twain's weather: everyone complains about it, but no one is doing much about it. ➔

For this artist, the sky is his canvas, his airplane his brush.

# *Smokin' Steve Poleskie*

by Stephan Wilkinson

Illustrations courtesy Steve Poleskie





To say that sky artist Steve Poleskie uses an airplane and smoke to trace out aerial patterns is like saying Paul Newman makes salad dressing—it's not the whole story. Leaving white contrails against blue sky is an obvious part of Poleskie's performance art, but it's not necessarily the most important element.

In a typical performance, Poleskie hammerheads and bunts in his Pitts S-1S biplane as a horn quintet plays on the ground below, its music composed to include the airplane's brassy little Lycoming engine as a surprising sixth. Alongside the musicians, dancers in Poleskie-designed costumes add their counterpoint to the airplane's own precisely choreographed maneuvers. Poleskie's Immelmans, humpty-bumps, and Cuban eights are often patterned to pay homage to, or make a statement about, something that has intrigued him on the ground. It can be the swell of nearby hills, a Civil War battleground, or a river splitting a city into working-class and yuppie turfs.

Poleskie is currently seeking sponsorship to perform one of his aerial pieces over the Axiom Art Center in Cheltenham, England, and one thing that particularly fascinates him about the Gloucestershire location is that it was a center for the production of the Gloster Meteor, England's first operational turbojet. Whatever maneuvers Poleskie designs, some of them will certainly be intended to evoke that stub-winged but shapely Royal Air Force fighter.

Sometimes the maneuvers exist only on paper, with smoke trails sketched on photocopied photographs of flying sites, or in large, circular collages that depict the movements and sounds of a performance that

*Steve Poleskie's Pitts performs a RrrrrmAOOW (top). Before a performance in Virginia, the Cornell professor planned the shape of things to come (left).*

*Poleskie sketches out his flights ahead of time, but once in the air he sometimes wings it.*

*Poleskie's swoops for the College of William and Mary were timed to music and dancers.*



Stephan Wilkinson



may never be flown. Among the more recent are some dazzling diagrams that Poleskie completed for exhibition last summer in Kassel, Germany, at a sky-art show to accompany the quadrennial Documenta exposition of modern-art trends. *This picture has no north no south no top no bottom* the border of each collage repeats in a loop, and so it is with Poleskie's sky art. The patterns he flies are meant to be viewed from an infinite number of points below, with different dimensions and meanings for each spectator.

Is this a legitimate form of art or simply conceited skywriting? "If the intent is different, the result is different," says Poleskie, 48, explaining for the who-knows-how-many-hundredth time why he has devoted 18 years and much of his income as a Cornell University professor of art to refining the intents and meaning of his patterns in the sky. "How does the Michigan State Marching Band differ from Balanchine's dancers? They're both groups of people moving through space to the accompaniment of music, but the intent of each is different. I want to take what have always been simply airshow maneuvers and make them dramatic and beautiful, not just an interesting thrill. The Rockettes all kick together, and that's interesting, but how much more meaningful and beautiful a ballet dancer is."

Sound and movement are as important to Poleskie as the painter's line and color, and his conversation is punctuated with pop-art *PAFs* and *BINGs*, *WHAPs* and *ROWRs*. (Listen to him describe a performance, imaginary stick wagging, one hand doing aerobatics: "You pull back here—*mmmmmmAAAOOOW*—and then you're over the top—*waaaaaAAAH*—and on a vertical line—*VOOOOOOooooo*—with a roll on the way down—*ROWrROWrROWr...*.)

Poleskie knows his airplanes. In the mid-1970s he flew serious competition aerobatics and professional airshows in the Pitts, "because I didn't want to be just the goofy Cornell professor who flops around in a biplane," he says. In 1977 he won the Canadian open aerobatic championship, and he holds the airline transport pilot rating to which every serious aviator aspires. Besides the Pitts, he owns a Piper Apache with a smoke-generating system on each of its two engines. The Apache can also carry three passengers, who thus become part of a Poleskie performance.

Poleskie learned to fly in order to paint conventional canvases from an aerial perspective, a project that quickly

R. Jessup



disappointed him. "If the art is less than the reality, it's not art," he says. "I'd sit in the airplane and look 50 miles in every direction, and it was impossible to paint anything that conveyed that." He turned his gaze on the vehicle itself, fascinated not only by aerial choreography but also by the symmetry of the airplane. He decided to paint his Pitts, using a paint scheme intended to combine the forms of Southwestern Indian art with the sweeping positive- and negative-G maneuvers of an aerobat. Poleskie also wanted it to reflect the avian coloration that makes male birds stand out. (Male bird that he is, Poleskie can't resist preening: the airplane's design is cluttered with decals marking his various aerobatic competitions.)

Poleskie was amused by the reactions photographs of his Pitts drew during a recent visit to the Soviet Union. "They'd say, 'You painted this airplane any color you wished? Didn't that confuse the military? Isn't it against the law?' And they were shocked that I used it for such a decadent purpose—just to do art rather than dust crops or carry pediatricians to remote villages. But when I explained I made *free* art for the people, that every worker sitting on a tractor could see it, that made it okay."

Poleskie, too, is pleased that the aerial theater is accessible to thousands on the ground who don't have to pass through the filters of critics, art galleries, and museums. "I want the art to be accessible to the people and then I want it to blow away," says Poleskie. "No copyrights. People can take pictures if they want."

Poleskie works alone, which can create problems when he must fly while coordinating

*By the end of Poleskie's piece over New York City, the beginning was gone with the wind.*

choreographers and musicians on the ground. "I usually have to fit into whatever existing structure there is," he says. "For a recent performance in Toledo, Ohio, I spent most of the winter corresponding with one dance group, since the budget allowed only for a local group, and when I got to Toledo, it was, uh, mutually determined that we weren't right for each other. So I had to abandon everything that had been done over the winter with only two weeks to rehearse a new group."

Sometimes life aloft is no easier. "I was

doing a performance over Stanford University in California once," Poleskie recalls, "and the line from the smoke-oil tank to the exhaust pipe of the Pitts broke. In the instant it took me to realize it, the pump kept running and blew a tremendous amount of raw smoke oil back through every little crack and grommet in the fire wall, into the cockpit, all over me, my sunglasses, my goggles, the windshield, and everything else. The landing was no fun. It's a problem to land a Pitts under the best of conditions, but when you can't see besides, it becomes really thrilling."

Ultimately, Poleskie would like to forego such thrills by directing the performance of his pieces by radio from the ground. He visualizes four or five Pitts airplanes, each a thousand feet higher than the last, in a dance of depth and complexity that would leave the show stunts of aerobatic teams looking as pallid as synchronized swimming. "In fact, it would be fun to somehow get the Air Force Thunderbirds involved," he muses. "I'd also love to find colored smoke that looked right and that wasn't based on liquid dyes that

*The sight and sounds of Poleskie's Pitts S-1S play an integral part in each performance.*

*Over the Hudson River, Poleskie's art work would prove fleeting, but memorable.*

Stephan Wilkinson





stained the airplane. Then I'd get something like a de Havilland Heron with four engines, each pumping out a different color."

Even far less ambitious performances cost money, however, and Poleskie's occasional commissions rarely come from private collectors, since there's little left to collect but "documentation"—preliminary drawings and collages, photographs and videotape. Work commissioned in the past has included flying in the June Jubilee for the Federated Arts Council of Richmond, Virginia, performing a piece in the Toledo Festival for the Ohio State Council for the Arts, flying in an Earth Day celebration for the State University of New York at Brockport, and performing four pieces over the campus of the College of William and Mary in Williamsburg, Virginia. But Poleskie's commissions are the exception more than the rule, and the bill often comes out of his teaching salary.

That has advantages: he doesn't have to fly in bad weather just to meet a sponsor's schedule. And his independence has allowed him to fly a series of "Unannounced Pieces"

over New York City, New England, and other prime East Coast locations. But "every time I do a piece," he says, "there's at least \$250 or so out of my pocket, what with gas, smoke oil, and time on the airplane." Buying and licensing the Apache's smoke system—a unique installation that had to be approved by the Federal Aviation Administration—cost \$4,500 alone. The expense also limits his palette. "After doing my first piece at 10,000 feet in the Apache, I discovered that generating smoke produces more exhaust back-pressure than I'd imagined," says Poleskie. "I was barely able to maneuver up there, so I went out and priced turbochargers, but there's no way I could afford them."

If it all goes up in smoke, Steve Poleskie, perhaps alone among fine artists, has the credentials to give it up and become an airline pilot. But wouldn't driving a bus with wings be boring for an artist? "You can't imagine what it's like to teach art to college students," Poleskie says, "how many thousands of bad pictures you have to look at. *Nothing* could be that boring." —

*To open the opera season in Verona, Italy, Poleskie conceived a noteworthy performance.*

# *Dash 80*

by R.G. Thompson

Boeing bet it all on one airplane—and got more than its money's worth in the gamble.

Shortly after 3:30 p.m. on July 15, 1954, at Boeing Field in Seattle, a pilot who would have been tall even without his cowboy boots climbed down from the cockpit of Boeing's Model 367-80 and allowed that "she flew like a bird, only faster." Alvin M. "Tex" Johnston had just completed the maiden flight of what the Boeing crew had come to call Dash 80, after the final digits in its model number. Now that its first flight had been smooth as silk, the big four-engine jet, the prototype for the country's first jet airliner, could finally be called an airplane.

Johnston may well have been so nonchalant because he knew that the prototype for the 707 commercial transport and KC-135 aerial tanker was no great engineering gamble. Boeing was the world's foremost builder of large military multi-engine jets, specifically the B-47 and B-52 bombers, and





*This ice machine, which proved that Dash 80's engines could withstand icing in flight, was only one of dozens of test devices that sprouted on the compliant airframe during its long career as a Boeing workhorse.*

*After Mrs. Boeing christened Dash 80 in 1954, William Allen found proving the worth of his company's \$16 million investment no bed of roses.*

The Boeing Company



Dash 80 was a logical descendant. In the accounting ledgers, however, it was a huge gamble—\$16 million in long-term red ink. After that first flight, and for a good while to come, Boeing would not have a single order to show for its investment.

The gamble eventually paid off, of course, in the sale of thousands of jet transports and tankers, in the domination of today's market for transport fleets—and in the creation of the remarkable Dash 80, whose performance, usefulness, and longevity as a company aerial laboratory for new designs far surpassed its backers' visions. In its 16-year flying career, Dash 80 made true believers out of the doubters in the commercial transport industry, who thought jets were uneconomical and ungainly. It flirted with the speed of sound, hung on the air by its claws at speeds as low as 80 mph, and served as the trainer for the first generation of commercial jet pilots. It gave birth to ingenious control surfaces and gave pilots their first look at video display cockpits and scores of other new instruments. It landed in mud as a double for Boeing's version of the C-5A Galaxy, and it represented its builder in the SST race.

But as spectacular as Dash 80 was at its debut, a swept-wing, four-engine jet was anything but a hot item in the airliner market of the mid-1950s. The airlines had balked at the idea of a jet transport from the late 1940s, when the concept had first surfaced. The air carriers were still paying for the enormous number of piston-engine aircraft they had just bought as replacements for pre-World War II equipment. Price-conscious airline executives thought jets would cost more to purchase and fly than their current fleet. They doubted that jets would fit into small airports and that an air traffic control system designed for smaller piston-engine aircraft could manage them. They worried that passengers would never accept air-

planes without propellers. And these were Boeings. Virtually every airline had been buying Douglas aircraft for years. Boeing built bombers.

Despite the odds, Boeing president William Allen was determined to launch the commercial jet age and put his company in the lead. A reluctant executive, Allen had served as Boeing's lawyer for 17 years before being virtually dragooned into accepting the president's job in 1945. Although he had almost no experience in aviation, in a remarkably short time Allen had acquired a grasp of the company's true position and possibilities. He realized that no competitor had Boeing's experience in jet design and manufacture, but the company suffered from a near-total dependence on military contracts. He knew that another piston-engine airplane would pose no threat to Douglas' primacy in airliners. What Allen needed was a credible presence in the market.

Boeing's only commercial transport at the time was the Model 377 Stratocruiser, a wonderfully comfortable but woefully uneconomical failure. A mere 56 had been sold at a loss of more than \$13 million. Fortunately, the KC-97 military tanker derived from it had more than covered the bills. If Boeing's piston-engine aircraft were faring poorly, the jet transport picture was even worse. The Boeing sales force had been soliciting orders for a commercial jet for three years with no luck. On the military side, the Air Force was also pinching pennies. It had refused to participate in the development of a jet tanker that would match the performance of its jet bomb-



ers. The Strategic Air Command could jolly well get by with its KC-97 tankers, even though the speed and altitude limitations of these slow, fat flying barges made the task of refueling fast, high-flying jets a dicey proposition for the crews on both ends of the refueling booms.

Believing that an airborne demonstrator would tip the scale in both the commercial and military markets, Allen met with his board of directors in May 1952 and persuaded them to bet every penny in Boeing's coffers on a one-design, two-market prototype. He pushed for and won a \$15 million commitment that later went up another million.

It was probably Allen the lawyer, not Allen the executive, who carried the day at that long board meeting. Although he may have cited the company's lead in large-jet design and the eventual inevitability of the Air Force switching to jet tankers, it seems far more likely that he concocted a brilliant case designed to woo a jury rather than drawing up a reasoned strategy for investors. The minutes of that meeting remain locked up at Boeing, so very few people know what actually transpired. But whether it was the lawyer or the executive who won, any dissenters on the board would have long since rejoiced that one of them did.

Work got under way virtually the morning after the meeting. The project was code-named 367-80, to encourage competitors to think Boeing was having its 80th go at a variation of the Model 367, the company's designation for the KC-97 prototype. In fact, Boeing's preliminary design for a jet transport

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*Suspending paired engines in pods beneath the wing began with the B-47 (above), but if one engine blew up, it took its neighbor with it. Dash 80's designers put only one engine in each of its four pods.*



*Engineers slapped a fifth engine on the aft fuselage while developing the tri-jet system for Dash 80's ubiquitous descendant, the 727.*



*Thrust reversers, designed to shorten runway roll after landing, were tacked on tufted engines and tested for airflow and efficiency. This candidate—and many others—lost to a folding-W design.*

The Boeing Company



*Boeing executives and engineers occasionally traded their suit jackets for parachutes and flew with chief test pilot Tex Johnston (at left), whose cowboy boots hinted at an independent nature.*

had been in the works since the late 1940s. Construction of the prototype began in a walled-off corner of Boeing's Renton, Washington plant in November, and the rollout took place in May 1954—just 18 months later. The next year, Douglas decided to skip the prototype stage and go ahead with production of a four-engine jet called the DC-8.

To those who thought the Douglas DC-7 and the Lockheed Super Constellation were immense, Dash 80's 128-foot fuselage and 130-foot wingspan were shockingly huge. But it looked like a pretty ordinary piece of work to the folks at Boeing—not that large compared to the B-52, and perhaps even a bit conservative in wingspan.

It was not the size but the design of the wings and engine mounts that gave Boeing its most important lead over its competitor. The 35-degree sweep of the wing and tail had been established through research that included a series of flights in a Bell L-39, which was a Bell P-63 with its wings swept. The same angle had been used on both the B-47 and B-52. With this angle, Dash 80 turned out to be 20 mph faster than the DC-8, with its 30-degree sweep.

The practice of mounting engines in pods on pylons below the wing began in 1947 with the B-47. Suspending the engines from pylons left room in the wings for fuel tanks. And in a crash landing, a pod could break away without damaging a wing or rupturing one of its fuel tanks. Unlike the bombers, which had their engines in pairs, Dash 80's design called for a single engine in each pod, so if an engine blew up, it wouldn't damage its neighbor. The arrangement also provided a more even distribution of the engines' weight and allowed for lighter wings. And the pods opened up so that airline mechanics had easy access to each engine.

It was an impressive design, but not perfect: Dash 80 had some bugs in its tail assembly and landing gear, and test pilots Johnston and Richard "Dix" Loesch, along with engineer James Gannett, were responsible for shaking them out. Boeing could not have brought together three more diverse personalities. Chief pilot Johnston had all the swagger you expect in someone named Tex, though he could be reserved when he talked about airplanes. Gannett was his exact opposite, wiry and quiet. Loesch was the most reflective of the trio and easily the most emotional about the project and his memories of those days. But then, it was his luck to catch some of Dash 80's wildest rides.

Landing an 80-ton airplane at speeds of 150 mph and less had been done before. But using only the wheel brakes to get one stopped within 6,000 feet on a wet or icy runway hadn't, and that was as much room as the largest airports of the day had to offer. Large military aircraft landed on 10,000-foot runways with the assistance of a drag chute, an impractical system for airline operations.

Faced with these constraints, Boeing designers gave Dash 80 thrust reversers to accomplish what the reversing propellers on piston-engine aircraft did to reduce ground roll distances after landing. After evaluating three final candidates, the designers chose the folding W-shaped design that is now seen on the aft end of almost all jet engines. They also came up with a new version of the conventional tricycle landing gear, one that gave test pilots and engineers many headaches.

On the eve of the scheduled maiden flight, the left main gear



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*More than 1,600 flights produced a steady stream of data that led to a host of aerodynamic innovations and an entire*

*family of Boeing airliners that dominate today's commercial transport fleet.*

collapsed after some taxiing tests. "Well, now is the time to learn these things," Johnston said as he stepped out of the airplane. Dash 80 lay on the ground like an exhausted bird. At least the gear had performed as advertised: it broke away without damaging the wing or the fuel tanks. Dash 80's first flight was postponed while engineers beefed up the gear structure and healed minor wounds.

Less than a month later, the airplane lost its nose gear. It happened after Johnston had been heating up the brakes with a series of high-speed ground runs and stops, then taking off to see what happened in the cold temperatures aloft—"cold soaking," as engineers called it. What happened was an expansion of the hydraulic fluid on the ground and a contraction in the air. Unbeknown to Johnston, the hydraulic system responded by forming bubbles in the lines, which sensors interpreted as a broken brake line. Performing as designed, the sensors promptly shut off fluid flow to the brakes.

Johnston landed daintily, stepped on the brakes, and realized he had none. On one side of the field sat a row of private aircraft; on the other, a line of B-52s. Johnston had one place to go: a grassy median between the two runways. He hoped the soft earth would slow Dash 80 enough to let him swing the airplane around and roll to a stop. He recalls a sudden crunch. Contractors making runway repairs had left a big block of concrete exactly where Dash 80 would find it. It knocked the nose gear off and damaged the belly, but Boeing had Dash 80 flying again in about three days. A redesign of the braking system sensors solved the hydraulics problem.

Not long after that, Dash 80 chalked up a midair landing

gear explosion and fire when the new anti-skid brakes turned out to be spectacularly efficient heat reservoirs. Johnston had heated the brakes doing ground runs, then had flown with the wheels down for 15 minutes to cool them. But as soon as the landing gear was retracted, there were several explosions accompanied by the smell of burning rubber. "There was smoke everywhere," he recalls, "so I speeded up, put the gear down, and blew the fire out." He didn't need brakes to stop after landing—5 of the 10 tires were flat.

The final thrill involving Dash 80's gear occurred during a test of the thrust reversers. After a series of landings, a hydraulic line let go and the flammable fluid leaked out onto a hot brake. The resulting blaze caused the crew to holler for the fire truck and abandon ship. Boeing replaced the entire hydraulic system with one that used less flammable liquid. "It was just another part of the learning curve," Gannett said.

There were also problems with the design of Dash 80's tail. All three test pilots had been aware of them from the start of the test flights, and apparently they were noticeable to others as well. However, they were not great enough to prevent Johnston from doing a seemingly impromptu barrel roll in front of 200,000 spectators. Then, for anyone who had missed it, he rolled Dash 80 again. In fact, Johnston's famous rolls were a sort of pointed rebuttal. "I'd heard that Douglas was telling people our prototype was an unstable airplane," Johnston says, "and I believe that when you fly for a company, you sell the product by demonstrating what it can do."

The International Air Transport Association was meeting in Seattle, and airline executives from all over the world were

The Boeing Company





*Takeoffs and landings on muddy California lake beds covered with dust proved that doubling the number of tires would allow a heavy aircraft to negotiate surfaces about as supportive as yogurt (left).*

*Wearing a needle-nose sensor and a cheerful face painted to honor its 11th anniversary, Dash 80 and an onboard computer researched the landing characteristics of supersonic designs (above).*



scheduled to be at Lake Washington for the Gold Cup hydroplane races. "I knew we had to do something to impress 'em," Johnston recalls.

Earlier, when Allen had asked him to fly over the race course, Johnston decided he would impress 'em by rolling Dash 80. Copilot Gannett had gotten an inkling of what was coming several hours earlier, when Johnston flew the airplane through a couple of rolls during a test flight. Allen, however, had no idea. When he looked up and saw his company's biggest investment on its back, he looked like a clinical example of apoplexy, according to people seated near him. Everyone loved the stunt, but Allen never got over it. He fired Johnston at least a thousand times before they met the next morning and cooler heads prevailed. Nonetheless, the infamous maneuver was a forbidden subject in Allen's presence for many years. At his retirement dinner in 1980, he was given a huge photograph taken from one of Dash 80's windows while the airplane was upside down. He left it behind.

*Photographic evidence of the infamous barrel roll, which nettled William Allen right up to retirement, was snapped by a quick-thinking photographer on board a Dash 80 demonstration flight.*

The stunt may have impressed airline executives, but it didn't cure the problems in Dash 80's tail fin, which had both a bad case of flutter and persistent Dutch roll.

Flutter is a vibration in the airframe that is induced at high speed in response to aerodynamic forces. It usually arises on an extremity, and, if left unchecked, it can intensify until it breaks up the strongest airframe. Dutch roll—so called because of its resemblance to the rolling side-to-side gait of ice-skating Dutchmen—occurs in all airplanes, but is harder to check in those with swept wings. As the airplane yaws from side to side, one wing advances and develops additional lift, causing the airplane to roll to the opposite side, which results

## **Something Old, Something New, Something Borrowed, Something Blew**

Boeing knew a lot about building large jets by the time it began designing the 707 prototype, but it learned even more in creating Dash 80. It also set the standard for many of the aerodynamic devices on today's airliners.

The basic structure of the fuselage came from the piston-engine Stratocruiser and relied on two main beams just below the floor line. A series of closely spaced oval rings was anchored to these to support the aluminum alloy skin wrapped around them. The number and proximity of these rings created a structure stiff enough to eliminate the need for interior supporting bulkheads, which meant more room for seats.

The engineers' goal was to land a 600-mph airplane at around 138 mph, about 40 mph faster than the speeds at which piston-engine airliners landed. But flight tests proved that was too slow to compensate for the response lag of early jet engines, so approach speed was increased to about 150 mph. As test pilot Dix Loesch put it, "We just couldn't live with the difficulty some pilots were having—and we couldn't go on semi-crashing the airplane." But higher landing speeds meant longer landing rolls, and that put the burden on the brakes.

Boeing had built several production 707s before it completed the design of a wheel-and-brake system that dissipated the enormous heat generated by slowing a landing roll or aborting a takeoff. And the design efforts could be counted in the number of wheels and tires destroyed. The heat could build so fast that the wheels would explode, an experience Loesch describes as "worse than a war." Finally, Boeing built a fuse into the wheel that melted if the rim got too hot, causing the tire to go flat rather than explode.

Placing the engines in pods suspended beneath the wing had numerous advantages, some of them surfacing after the fact. It was discovered that the pylons acted as air dams, confining airflow past the wing to a straight path despite the sweep angle and thereby conferring straightforward stall characteristics when airspeeds dropped so low the wings could no longer create lift. Usually, unencumbered or "clean" swept wings behave like broncos under such conditions because the airflow begins to turn outward, as if herded toward the tips by the wing's sweep. Portions of one wing inevitably stall,



The Boeing Company

causing the airplane to roll, sometimes uncontrollably—as chief test pilot Tex Johnston had learned in the swept-wing version of the P-63.

The greatest challenge Boeing confronted was dealing with a phenomenon called "aeroelasticity." Aeroelastic wings, which flex in rough air, are thick at the root, thin at the tip, and covered with a skin that also thins progressively outward. Their long, thin design resulted in aerodynamic efficiency at high speeds with a minimum penalty in extra weight. Boeing had vast experience in building such wings for its jet bombers but turned to a thicker structure and thinner skin for Dash 80's wings. Fully controlling such a wing called for an impressive array of surfaces, which Boeing borrowed from the B-47 and B-52 and combined in a new design for its airliner.

The trailing edge of Dash 80's wing had, reading from root to tip: a set of double-slotted flaps for extra lift at low speeds, a small aileron or "feeleron" that fed control responses back to the pilot, a second set of double-slotted flaps, and an outboard aileron. On its upper surface and just ahead of the flaps, each wing had two spoilers—rectangular panels hinged on their leading edges that could be pushed up into the passing air, thereby "spoiling" its smooth flow.

The spoilers worked in one of two configurations: all pushed up together to spoil lift and increase drag for use as speed brakes in rapid descents, or independently, in conjunction with the feelerons, as roll controls at high speed. The latter configuration solved a big problem with outboard ailerons at high speeds: when deflected to roll the airplane, they could bend a flexible wing in the opposite direction. Johnston had learned this years before, while flying a B-47 at 500 knots a few hundred feet over the southwestern desert. He turned the controls to bank left—and the airplane rolled to the right. Spoilers appeared as roll controls on

experimental B-47 wings shortly after that ride, as engineers learned where to position them. Feelerons, also called high-speed or inboard ailerons, first appeared on the B-52.

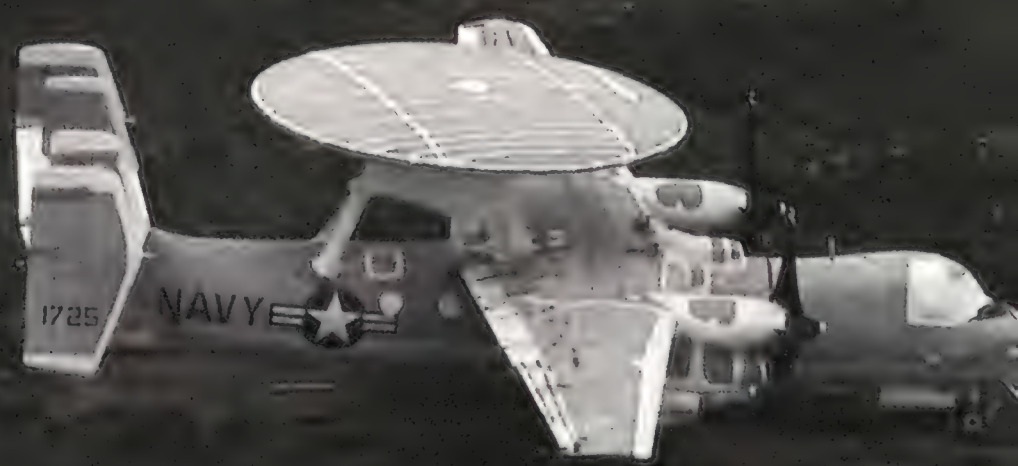
On Dash 80, roll control came from a combination of the feelerons, which were mounted farther inboard and were too small to twist the wing, and the spoilers, which caused the wing to drop by spoiling lift over it. Whenever the flaps were retracted, the airplane was considered to be in a high-speed flight mode and the troublesome outboard ailerons were locked into a neutral position, as if they were a fixed part of the wing. They resumed their control role at slower speeds when the flaps were lowered.

Dash 80 started with a rudder that relied on pure muscle power, marginally aided by tabs that used passing airflow to help the pilot, who had to push mightily on the rudder pedals. The assistance of a hydraulic boost system was long resisted by the airlines, who wanted old-fashioned cable because, dammit, cable did not leak and leave you with nothing. Johnston still believes that short-legged pilots would have had a problem with manual rudder control in difficult situations—a dead outboard engine could require up to 100 pounds of constant pressure on a pedal to compensate for imbalance. Eventually, a hydraulic boost completely tamed the big rudder.

Vortex generators, rows of tabs on the upper surface of the wing that persuade air passing at speeds near the stall point to stay glued to the wing instead of bubbling away, were borrowed from the B-52. And the leading edge, initially a clean, solid sweep of metal, grew all manner of slats and flaps to change the angle at which it met the oncoming air. In an effort to enhance airflow over the wing, Boeing experimented with a system that drew air from the engines and blew it across the top of the flaps. With these "blown flaps," Dash 80 could be overtaken by a DC-3, but that was low-end performance nobody really needed. Besides, the ducts that transported the air took up so much room the flaps couldn't be retracted.

In retrospect, it seems as if every aerodynamic device applicable to jets was stuck on this compliant airframe at one time or another. Boeing simply kept the ones that worked.

—R.G. Thompson



in a combined rolling and yawing motion. If this motion continues, it creates a cycle of alternating, increasing yaw angles that can result in uncontrollable roll.

Dash 80's original tail fin was short, compared with the fin on the B-52, and not much of a yaw inhibitor. Its size, coupled with the lack of a power boost for the rudder, may have contributed to its tendency to flutter. "Flutter... it was a black science then," Dix Loesch says. "When the flutter guys started talking to their bosses, everybody else just sort of looked at the ceiling."

Johnston hunted for flutter in Dash 80 early on, and he found it near maximum speed, where it can be expected. Even though the flight engineer's instrument panel was shaking so hard the mounting bolts broke, Johnston coolly reported, "We're experiencing an appreciable vibration up here." Later, however, Loesch encountered flutter during normal climb.

"I did the normal things to fight it—leveled out, throttled back. They didn't work. I thought the airplane was going to shake itself to pieces. All of a sudden the rudder froze, and the flutter stopped." A minor structural failure saved the day—a balance weight had broken loose and jammed the rudder.

Whatever it was that caused Dash 80 to shake, rattle, and roll, Boeing discovered that changing the fin's internal balance weights, increasing its size, and adding an electronic yaw damper and a hydraulically boosted rudder control ended the problems with flutter, yaw, and Dutch roll.

Late in 1955, orders started trickling in, then flowing. Douglas' DC-8 orders were not far behind. By the end of 1959, 100 707s had rolled off the production line at Renton, and the first of several hundred KC-135s had been delivered to the Strategic Air Command. Dash 80's career as a prototype and dealer demo was finished, but Boeing was not yet ready to put it out to pasture.

In the early 1960s, Dash 80 was used to test some modifications that would later show up in the 727. These tests led in turn to a long stint with NASA and Boeing testing wings that can generate enough lift for the airplane to remain airborne at extremely low speeds. Dash 80 had averaged 612 mph during a transcontinental speed record flight in 1957. Now it was creeping around Seattle skies at 80 mph and landing at 92 mph. Dismayed commuter airline pilots had to S-turn their Douglas DC-3s on final approach to Boeing Field to avoid overrunning what appeared to be a 707. To preserve control at such ridiculously low speeds, Dash 80 sprouted a lush profusion of leading- and trailing-edge devices on its wings. Their appearance alone was enough to make test pilots blanch.

Gannett continued to fly Dash 80 throughout the low-speed tests, but Johnston and Loesch had moved on and were replaced by S. Lewis Wallick, recently retired from Boeing, and Thomas Edmonds, who is still a test pilot there. In tests of leading-edge slats for the wing, engineers experimented with the curve of the slats by applying the file and fiberglass to the devices between flights. Leading-edge symmetry is critical—

*Retired to the preserving climate of the Arizona desert in 1972, the goose that laid Boeing's golden egg rests amid military relatives, awaiting a final flight to the National Air and Space Museum.*

without it, an airplane tends to roll uncontrollably in a stall. This imprecise shaping of the wing made for occasional imbalance and some very sporty flying. Edmonds recalls a day when one flight was enough: "We stalled, rolled over to about 90 degrees to the horizon, did a split-S, and ended up headed in the opposite direction. We looked around, kind of startled, and decided there was no point in doing any more stalls that day."

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**Dash 80's tail tended to flutter, and "flutter was a black science then," says Dix Loesch. "When the flutter guys started talking to their bosses, everybody else just sort of looked at the ceiling."**

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Dash 80 wore its high-lift wings to the end of its career, and Boeing and NASA engineers tested a series of design ideas that depended on solid control at slow speeds. The aging airplane was landed on grass, dusty lake beds, soft earth, and even mud, using a landing gear system being considered for what would become the Air Force's enormous C-5A Galaxy transport. The landing gear spread the weight of the aircraft over 20 tires instead of Dash 80's 10. The tires' flotation allowed the airplane to land on dust-covered mud only marginally more supportive than yogurt.

In 1965, with a long needle-like sensing unit, a comical face painted on its nose in honor of its 11th anniversary, and computer-mediated controls, it imitated the landing characteristics of a series of supersonic designs for NASA. A second set of controls enabled the copilot to take over and fly the airplane normally, a precaution that allowed the computer to crash without the airplane following suit. Dash 80 also tested scores of cockpit instruments and controls, some of which later showed up in the video display cockpits of the 757 and 767. But this was the stuff of swan songs.

On January 22, 1970, after completing the last of a series of flights designed to test an automatic landing system for the space shuttle, Dash 80 went into retirement. Its logbook showed 1,691 flights over 16 years for a total of 2,349 hours and 46 minutes, but it was not quite closed. In 1972 Boeing returned Dash 80 to nearly original condition for a reenactment of the record-setting cross-country flight. It ended in Washington, D.C., where Boeing presented the grand old 707 prototype to the National Air and Space Museum.

After the ceremonies, Wallick and Edmonds ferried it west to Davis-Monthan Air Force Base in the preserving climate of the Arizona desert. For the past 15 years, it has sat patiently at an aircraft storage depot, awaiting a slot at the Museum. The paint scheme Boeing once described as "an eye-catching blend of canary yellow, chocolate brown, and silver" has faded, but Dash 80's legend and legacy are likely to endure at least as long as its tired aluminum can hold together. —

by Steven L. Thompson

*Illustrations by Dale Glasgow*

When Air Force pilots take off into the virtual world of the future cockpit, the view is going to be spectacular.

Terry E. Eiler



# THE BIG PICTURE



It makes sense that Thomas A. Furness III is an avid reader of science fiction. And that he uses the location of Thomas Edison's New Jersey laboratory as a verb, as in "We're Menlo Park-ing that one." In his corner office on the third floor of Building 248 at Wright-Patterson Air Force Base in Dayton, Ohio, Furness is demonstrating how sci fi and his modern version of Edison's invention factory can merge. Together with a team of scientists, engineers, and technicians in the Visual Display Systems Branch of the Air Force's Armstrong Aerospace Medical Research Laboratory, Furness is doing nothing less than inventing a way for humans to forge a new relationship with machines.

"The problem is this," says Furness, leaning forward, his blue eyes flashing with evangelistic fire. "We're spatial animals in a three-dimensional world. But the machines we build to peer into that world talk to us in *two* dimensions."

The solution to the problem is a device called a "cognitive port" that will allow humans to place themselves in a completely imaginary "virtual world," which exists only as a mathematical model in the memory of a computer. Ten years ago, such technology would have existed only in science fiction. Today, it is computer hardware and software combined with a system called the "Super Cockpit" that will soon permit the Air Force's fighter pilots to better their odds for survival in battle. But its potential benefit reaches far beyond momentary military advantage. Furness' research could also benefit civil aviation and, ultimately, every interaction between humans and machines.

"Consider the modern combat pilot's problem," Furness says, turning to a projected image that shows the workspace in a McDonnell Douglas F/A-18. "Here is an example of one of our best new fighter cockpits." Furness allows a moment for study of the displays, dials, switches, and knobs. "Here is another example." The projector clicks and a close-up of a stick appears. "This is an F-15 control stick. Notice the switches growing out of this thing. Can you count 'em?" They sprout like bumps on a pickle. "I'll save you the trouble. There are nine." He pauses for effect. "Nine—and seven on the throttle! Can you imagine what that requires of the pilot who has to remember what each one does and then select the right one—*by touch alone?*"

**From the F-16 File:** *The Air Force's newest fighter was a vision straight out of the movie Star Wars. Its pilot lay in an ejection seat tilted back 30 degrees, the better to afford him protection from accelerations, or G-forces, caused by hard turns. A surrounding teardrop canopy provided him an unobstructed view of the world outside.*

*Pilots loved the new fighter from the start. But even after the first units had begun training in it, it still had no official Air Force name. Impatient, a group of fighter jocks from the*

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*To the pilot inside it, wearing this experimental helmet is like strapping on a television screen.*

## ***The Cockpit You Wear on Your Head***



**Helmet Position Sensor—**  
enables computer to  
determine position and  
orientation of pilot's head

**Image Projectors—**  
miniature cathode ray  
tubes generate virtual  
images that appear at  
correct distances

**Optical Pathway—**  
mirrors guide images to  
pilot's field of vision

**3D Sound System—**  
speakers produce sound  
cues and voice commands  
that "point" to information  
or source of data

**Helmet—**  
custom-molded to pilot's  
head, made of lightweight  
fiber composite, umbilical  
cable in back carries  
electronic data

**Touch Simulator—**  
fingertip device in glove  
provides position  
reference, creates  
pressure when pilot  
"touches" switch on  
panel image

16th Tactical Fighter Training Squadron and some other units went public with a suggestion.

They wanted something that reflected the swiftness, newness, and lethality of the F-16, they said. Their choice: Viper, after the rocket fighters on the TV show "Battlestar Galactica." The young pilots were looking ahead to space flight for their inspiration. But the top brass, who were looking back to memories of World War II, preferred names like Mustang 2, Persuader, and Eaglet. Predictably, the brass won out with the more mundane Fighting Falcon, and the furor died.

The F-16 by any name turned out to be one hot airplane, and the young fighter jocks really began pushing it—so much, in fact, that on occasion, bad things happened. Soon the Air Force was knocking on Thomas Furness' door.

You might assume that the growing use of video instruments and the evolution of electronics in the cockpit would solve some of the display and control problems for pilots, but that's not so, says Furness. "Generally, these electronic cockpits can display more data to the operator than the operator is able to assimilate . . . . Data or symbols on these displays are highly codified, requiring their meaning to be learned and responses trained at higher cognitive levels," he writes. "These panel-mounted displays (and even narrow field-of-view head-up displays) provide only two-dimensional 'peep holes' into a three-dimensional world. The failure [of these displays] is especially evident during high stress conditions when pilots complain that their 'brains tend to ooze out of their fingertips.' "

Machines that use traditional displays make the operator work too hard to figure out what the machine is trying to tell him. And once he figures that out, cumbersome controls make it difficult for him to tell the machine what to do next. Such machines, in short, make their operators do all the work. Fighter pilots aren't the only ones affected. Anyone who uses a traditional computer has the same problem: the computer's display, which provides only a narrow, artificial peephole into the computer's world, and its keyboard, which accepts control commands only as typed characters, are choke points that make working more difficult. Furness sees clear connections between the F-16 cockpit and the office desk, the processing plant, the assembly line—anywhere people and machines work together.

The problem that arises when three-dimensional humans try to work with two-dimensional displays is particularly acute in aviation. So the impetus (read: funding) for the basic research to find a solution to this problem has been coming from the U.S. Air Force, the Army's aviation programs, the Federal Aviation Administration, and the National Aeronautics and Space Administration.

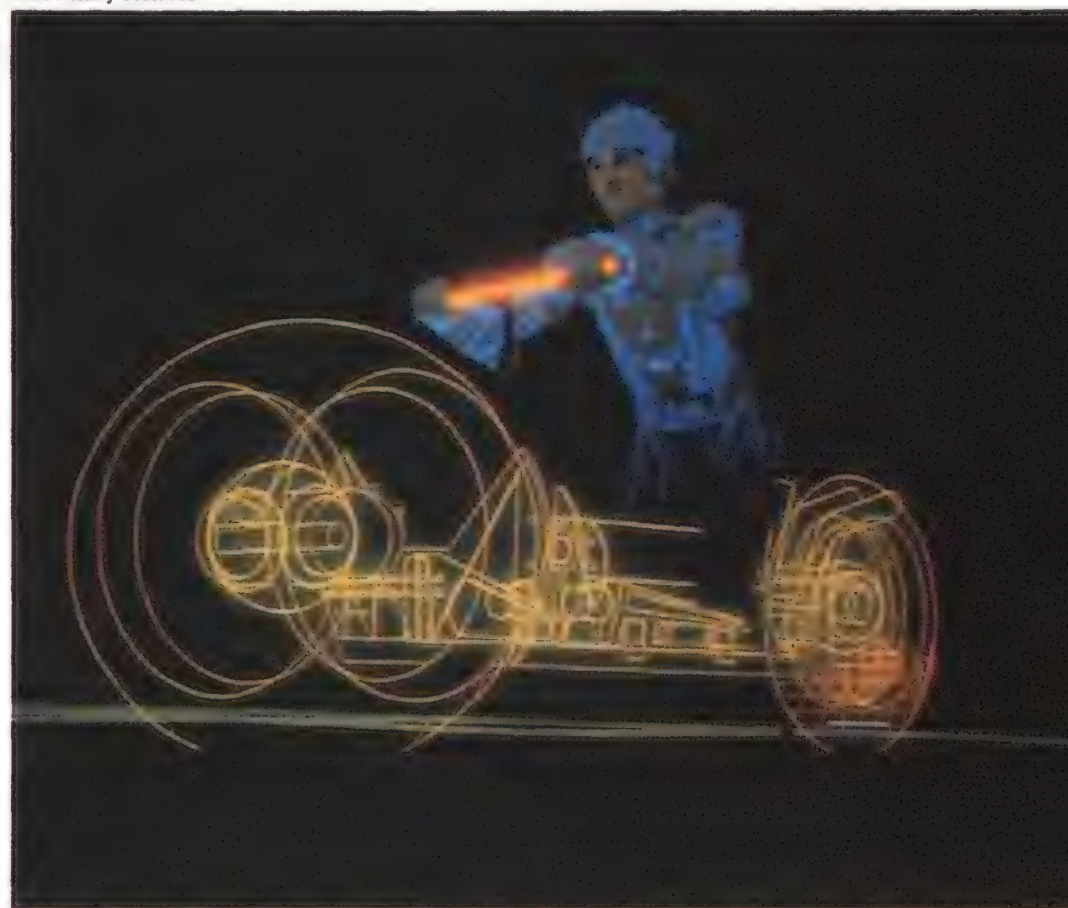
**From the F-16 File:** The airplane was too good. In fact, it was better than its pilots in one crucial way: it could maneuver so fast and hard that its pilots blacked out. It wasn't only that the pilot confronted more total G-forces than in any other combat airplane; the F-16 was so responsive, so tough, and so maneuverable that everything was happening too fast. Instead of building gradually, sudden "spikes" nine or ten times the force of gravity were slamming the pilot.

The flight surgeons recognized the adverse effect of such high G-onset rates but had no real fix, other than to suggest the pilots not fly so hard. Worse than the blackout was what followed it. Too often, the hapless pilot was in a state of sensory confusion for long seconds after regaining consciousness. He could not always read his instruments. His higher brain functions were ruffled by the blackout. And during the period of confusion, he was vulnerable to enemy action or simple loss of control of the airplane.

The pilot who succumbed to vertigo or sensory confusion while in darkness or cloud was in the worst fix of all. The odds that he could regain control of his airplane in time to avert losing it and himself were poor. Then the Air Force learned that you didn't even have to lose consciousness to be vulnerable to all this. As the F-16 operational hours accumulated, it turned out that sometimes the pilot's panoramic view from his bubble cockpit became a liability. He could be disoriented simply by flying for hours in clear conditions and then experiencing stress and entering cloud. As the Air Force explained to Furness, sometimes a pilot in that situation might have to stare at his instruments a long time before he could figure out what they were trying to tell him. Sometimes he just stared too long. And then, desperately trying to regain control, he might make a wrong move. And then another. In the accident report, it would say only that the aircraft had "departed controlled flight."

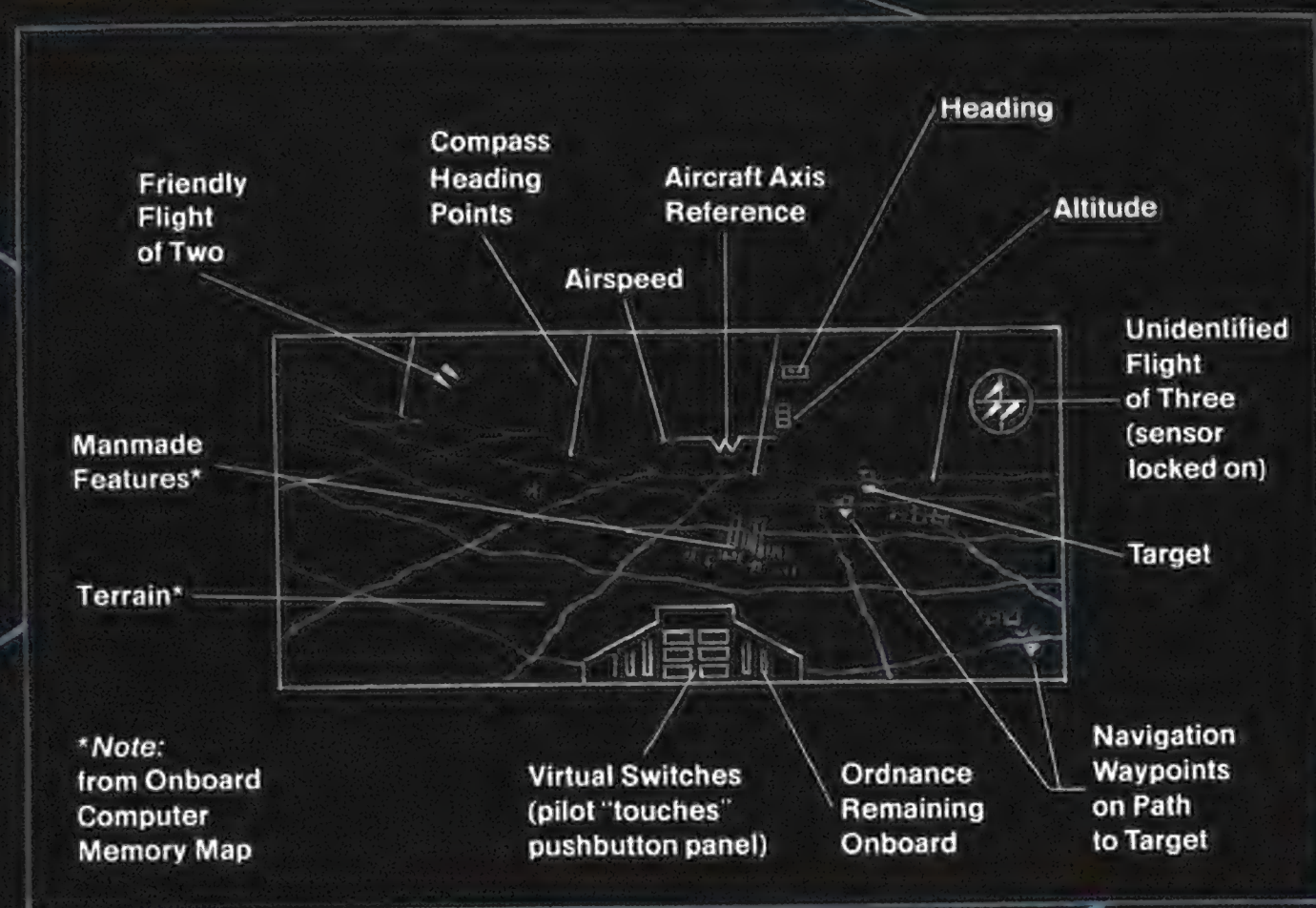
Furness was not surprised by the difficulties F-16 pilots faced. Having worked on visual displays for the military since 1966, as well as having flown backseat in McDonnell Douglas F-4s as a flight test engineer, he knew the problems first-hand. His research in the field of visual perception began in the '60s,

Walt Disney Pictures



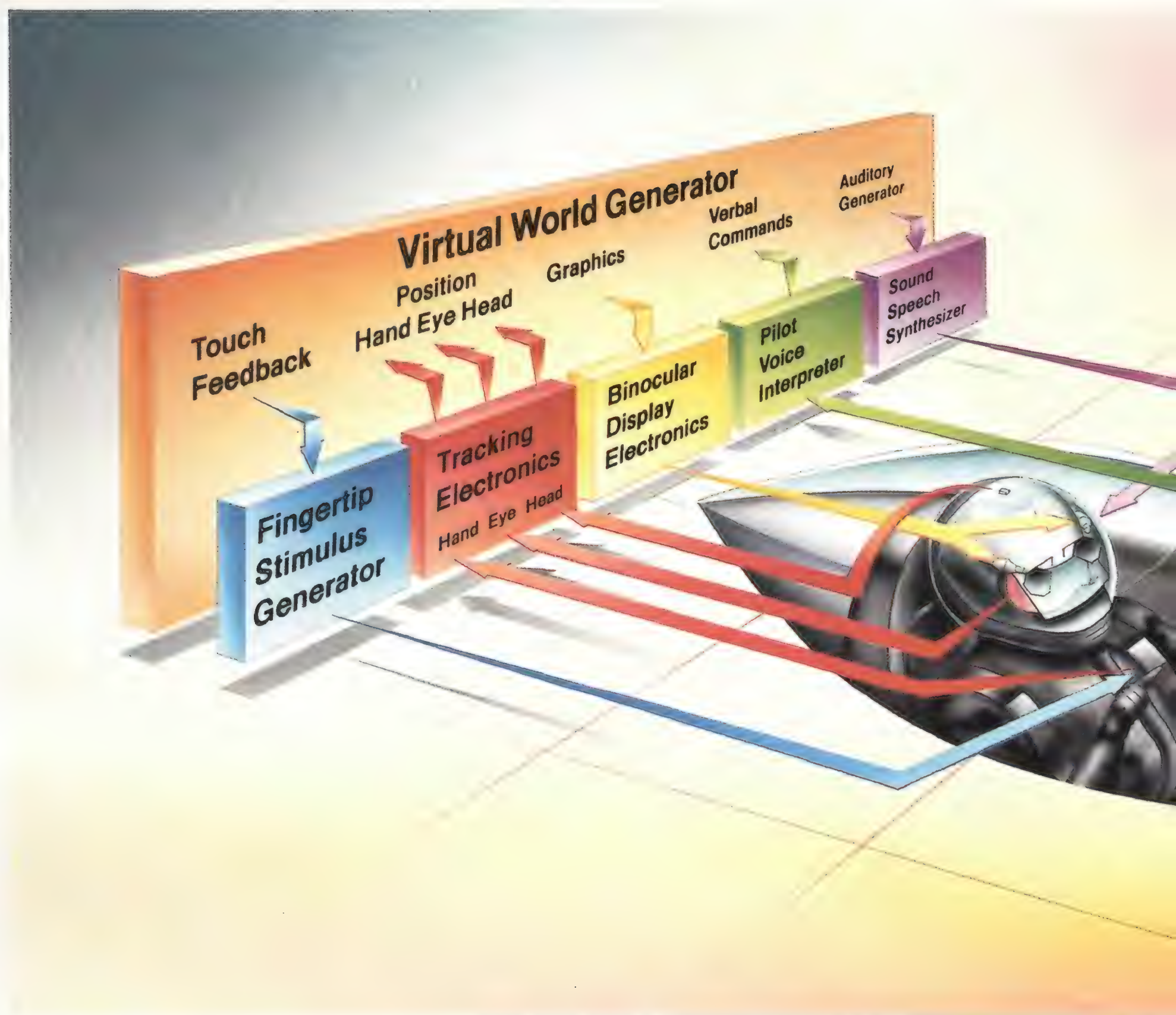
The Disney film Tron offered stunning and accurate images from a mathematically modeled universe.

## *A Pilot's View of the Virtual World*





## Super Cockpit Logic Pathways



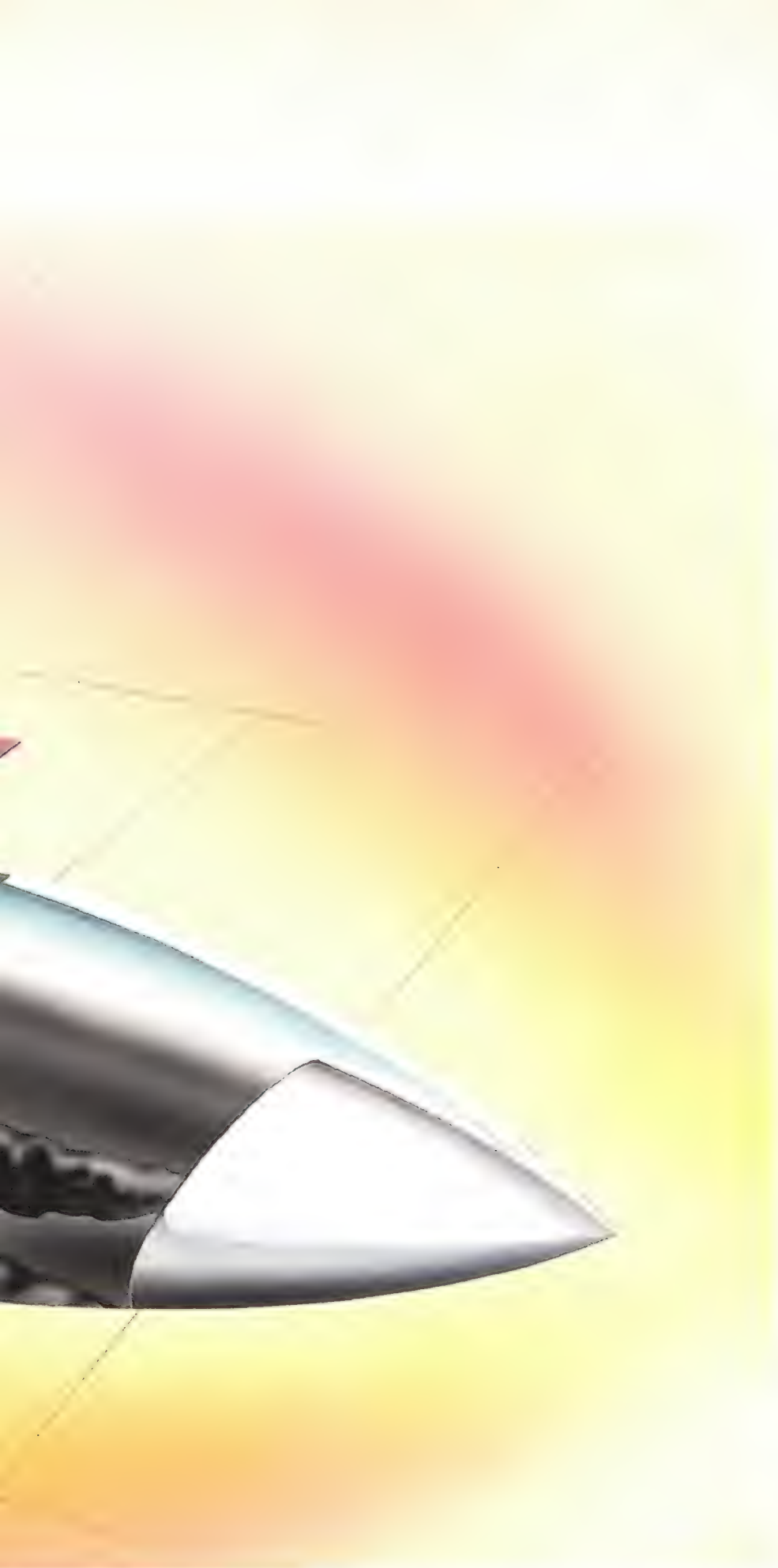
while he worked on his B.S. in electronic engineering from Duke University, and continued through 1981, when he earned his doctorate in engineering and applied science from the University of Southampton in England.

Knowing the problems is one thing, solving them something else entirely, as every applied scientist knows. Listening to Furness carefully describe his years of patient research in electro-optics, neurobiology, computer languages, and aircraft control technologies, you begin to understand that the difficulties are not solely technical. There are other dimensions.

The traditional cockpit display and control system had matured over 80 years, and although they were faulty, they were at least familiar. They embodied the state of the art, and the pilot's job is as much art as science. The Air Force's unofficial view of Furness' work was oddly ambivalent. The cockpit

clutter had to be reduced to enable pilots to focus on the most important tasks. But the older pilots who had become the funding masters, the guardians, in a sense, of the values of the Air Force piloting establishment, were also artists of a sort who were proud of their wisdom, experience, and craft. So though they knew that it was often difficult to interpret and react correctly to the narrow-bandwidth, cognitive-intensive information supplied by old-fashioned "steam gauges," they also believed that these skills were what defined a good pilot.

Laden with such psychosocial mythology, burdened occasionally with funding problems—"my number one headache," winces Furness; "compared with the paperwork of just trying to buy something, the technical difficulties are minor"—and perpetually confronting complex research hurdles, the program required Furness' evangelism to keep moving. Deep-



pocket sponsors had a way of appearing and disappearing, depending on the rise and fall of other programs, such as the Army's next-generation light-helicopter development effort and NASA's space station and shuttles.

Yet the Menlo Park atmosphere paid off, and in 1982, Furness and his colleagues (notably Dean Kocian, who had worked with Furness as an Air Force officer and then as a fellow scientist at Wright-Patterson) produced a working model of something they called VCASS, for Visually Coupled Airborne Systems Simulator. It resembled a huge Darth Vader helmet and was wired to a cockpit mockup and computer. Instead of flying by reference to the real world outside, pilots testing the VCASS were asked to accept a completely synthetic reality—a world of symbols generated by computer and projected directly into the pilot's field of vision *inside* the helmet. Indeed,

the pilot flying with VCASS couldn't see the outside world at all, and since that world had been replaced by an exact duplicate made up of symbols, he didn't need to.

VCASS wasn't pretty, but then it wasn't meant to be. Its job was to win over the people who counted most: the pilots. Despite—or maybe, in the case of the “Battlestar Galactica” fans, *because* of—its weird appearance, the first VCASS drew qualified raves from those who flew in its virtual world.

Even the qualified raves earned the program more funding, so Furness' team plowed ahead. From the research, startling detail emerged about how humans operate in their world. Researchers discovered the incredible spatial accuracy of human hearing: we can fix the direction of origin of a sound within a few degrees without conscious effort—a trait used for millennia by hunters, and one eagerly exploited by the engineers. In the virtual world, sound becomes a pointer, directing a pilot's attention very precisely. And the exact functional limits of the eye were mapped with equal thoroughness.

The research gradually revealed the extent to which we use our peripheral vision and hearing and the concomitant need to use our central “foveal” vision to analyze and process the information more thoroughly—to think about it. In the crudest terms, the research showed that to put the human faculties to best use, the ways we display information had to be completely altered; that we are much better at *sensing* our speed, direction, and position than we are at inferring it from a set of numbers displayed by instruments.

Armed with more research, Furness refined the concepts of VCASS. The next step was to add a voice-operated command that selected a particular weapon, cocked it, and fired, along with a system that would track the pilot's own eyeball motion to move a pointer that picked out targets. Now a pilot had only to look toward a symbol, determine what it was, and, if he wanted to shoot at it, utter a word or two that would do the job. The pilots loved it. When the tests were done, pilots who used the helmet in the simulator racked up impressive gains compared with the control group using conventional display.

Now tagged Super Cockpit, the assemblage of diverse technologies is rapidly coming together; at a recent briefing before a society of professional engineers, Furness was able to say that the limiting factor was no longer hardware but software. About 500,000 lines of programming must be written before the ultimate Super Cockpit can take off, he says. (By way of comparison, the Strategic Defense Initiative is expected to generate 10 million lines of code.) Although the hardware is complicated, much of it now exists, and the work remaining is limited to such tasks as upgrading the display from monochrome to full color, further reducing the helmet's size and weight, and incorporating the audio and video equipment in the helmet into a new or fully enclosing shell. The software tasks are more daunting, since the Super Cockpit master plan calls for major leaps at each of three stages.

The first leap envisions a functional system by 1990 that includes head-aimed weapons together with a display of flight situation and navigation data, plus weapon delivery and sensor control. Then Furness' group will hand off the project to another team, whose task is to refine the design and performance in order to prepare the system for production. Stage two, due in 1992–94, calls for adding to these capabilities

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**Nothing less than a real R2D2, the pilot's associate will become an electronic sidekick far more powerful than the lovable but not especially helpful robot.**

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three-dimensional sound cues and voice control of system functions. The final stage, in 1996, will complete Furness' vision. It is called "the pilot's associate."

The pilot's associate is nothing less than a real R2D2, just like Luke Skywalker's. It will be the pilot's "guy in back," an expert artificial intelligence dedicated to monitoring the airplane and the pilot's physical and mental state. The way Furness sees it, the associate will become an electronic sidekick far more powerful than the lovable but not especially helpful robot in *Star Wars*.

It's at this point that many seasoned pilots lean back and cock an eyebrow. Such things are fine in "reel" life, they say, where machines don't break for mysterious reasons, where contractors don't cut corners in ways that show up when your systems fail over the target, and where your maintenance is not done by 20-year-olds who can barely read. That's real life. How will a supersophisticated Super Cockpit, with this pilot's associate gadget, work—and keep working?

Furness' response: simple—self-repairing computers. Since Super Cockpit is like current military avionics but more so—that is, mostly software instead of mostly hardware—yet another task of the artificial intelligence will be to heal itself. Like much else in Super Cockpit, says Furness, some of this is already available: the computer industry today produces computers capable of circumventing damaged or flawed circuits and processors.

***From the Future Fighter File:** The best part was that the engineers didn't have to make the F-16 heavier to make it better when they installed the Super Cockpit. Indeed, by using photonics-based transphasors rather than electronics-based computer transistors—light instead of electric current—they reduced the weight of the computers so much that even the huge Defense Mapping Agency terrain database for the whole world weighed only four pounds. The pilot's helmet added only 3.2 pounds with its umbilical cable.*

*When he climbed into his F-16SC, the young fighter jock of 1998 simply plugged in his helmet and flipped down his visor to activate his Super Cockpit system. The virtual world he saw exactly mimicked the world outside. Salient terrain features were outlined and rendered in three dimensions by the two tiny cathode ray tubes focused at his personal viewing dis-*

*tance. Using voice commands, the pilot told the associate to start the engine and run through the checklist. Speaking to him in a voice (a female's, naturally, just like most synthesized voices used since the 1970s) chosen by the pilot himself, the pilot's associate performed the mundane but critical tasks and calmly reported when the airplane was ready while the pilot rehearsed the mission in his mind.*

*Once he was airborne, solid cloud obscured everything outside the canopy. But inside the helmet, the pilot "saw" the horizon and terrain clearly, as if it were a clear day. His compass heading was displayed as a large band of numbers on the horizon line, his projected flight path a shimmering highway leading out toward infinity.*

*A faint whine above and behind him to the left told the pilot even before the associate announced it that his "enemy"—a squadron mate designated as his practice attacker for the mission—was closing in. The sound grew louder and more precisely localized as the opponent approached. Using voice commands again, the pilot called up a window display in the computer-mapped three-dimensional control box in his cockpit. A large weapon display appeared, just as windows used to appear on old personal computers like the Apple Macintosh.*

*The pilot glanced at the weapon system he wanted and raised his left hand. Tiny devices sewn into the fingertips of his flame-retardant gloves gave off signals that were tracked by the associate. When he "pushed" on a phantom button on the virtual display, a confirming click and slight pressure to his fingertip was fed back to the pilot to verify selection. To anyone watching, he appeared to be poking at thin air.*

*The next move the pilot made as his enemy dropped down behind him was familiar to the associate, so it was ready when the pilot banked the F-16SC violently into a hard turn. The pilot knew he might black out from the sudden G-load, and so did the associate. Biomonitors in his helmet and flight suit confirmed it: two seconds into the evasive maneuver, the pilot lost consciousness.*

*Knowing the tactic the pilot wanted to use to turn the tables, the associate continued the maneuver. Standard procedure strictly forbade blackout-G turns except in life-or-death situations. But the associate had already learned what exasperated squadron commanders have known since the days of the Lafayette Escadrille: a fighter pilot is a fighter pilot, whether in a SPAD or an F-16.*

*The associate continued the turn, and the game.*

Furness says that the elements of the model system are cheaper and lighter than current avionics, and if that's true for the operational system, the implications for civil air safety are enormous. Since expert fighter pilots can be confused and disoriented by sudden transition from the visual world to the instrument world, the dangers faced by the weekend pilot in the same situation are even more severe. Federal Aviation Administration figures show that up to 40 percent of all general aviation fatal accidents and 52 percent of all air carrier fatal accidents are due to weather. If you can give a pilot the means to see and control in instrument conditions without having to perform high-level mental tasks just to know his speed and position, it's a safe bet these figures would decline dramatically.



But the most dramatic potential for Super Cockpit technology is not in airplanes, but on the ground. Furness foresees ways for the cognitive port to be used in teaching, allowing children to take their own fantastic voyages through everything from a single molecule to a complex mechanism. What the Super Cockpit helmet portrays, after all, is only what its sensors and computers tell it to portray—the virtual world. That can be the mimetic view of the world outside an airplane canopy—or it can be . . . what?

Anything, is Furness' smiling answer. Anything at all. Anything that can be detected and quantified by the increasingly sensitive array of sensors we've created, from radar to electron microscopes. So an engineer can test his design before he even builds the prototype; the architect can stroll through a foyer in a building he has only imagined; the surgeon can turn the two-dimensional slices of a CAT scan into a three-dimensional look at a patient's brain.

Once the key software is written, the last piece will be in place to transform Furness' technology into a powerful new tool for extending our senses. Where will this mechanism take us? Perhaps to places we might not particularly want to go. Air Force pilots won't like the obvious extension of the Super Cockpit concept, which suggests that if the pilot can be made

*Thomas Furness' research begins in cockpits but leads to a new link between people and machines.*

more effective by putting him in a world defined by sensors and computers, he should be removed from the aircraft entirely and data-linked to his fighting craft. The program already calls for an Airborne Battle Commander, who sees a replication of entire battles from an aircraft hanging safely back from the combat. Why not take the next logical step and move the pilots to a bunker far underground?

Not even Furness is willing to go that far, although he acknowledges the logic and technical feasibility of the scenario. He concentrates his efforts instead on perfecting VCASS and on the endless procurement battles to be fought.

The wonder of it all is that Furness is not working alone. Asked how many people contribute directly or indirectly, Furness simply shrugs. "Lots," he says, then adds, "With a program like this, *everything* is connected." And the way Furness says it suggests that not even he can envision the ultimate breadth of the landscape that will be revealed by humankind's new cognitive port.

Welcome to the virtual world. ➔



# The Curator of Cosmic Dust

by Alcestis Oberg

Stardust makes more than memories for Michael Zolensky—he knows it may help unravel the secrets of the universe.

*In one of the cleanest rooms on Earth, Zolensky carries cosmic dust in a plastic “coffin” (left).*

The title “Curator of Cosmic Dust” evokes a Merlin-the-Magician figure, a wizardly type with white beard, flowing robe, and peaked cap, throwing stardust about by the wandful.

“Actually, our entire collection of cosmic dust would probably fit on the head of a pin,” says Michael Zolensky, the boyish-looking 31-year-old who works for the National Aeronautics and Space Administration and bears the imposing title. Preserved in his laboratory are microscopic particles from comets, meteorites, and possibly even distant stars, which Zolensky and coworkers at the Johnson Space Center in Houston, Texas, painstakingly analyze and make available to researchers studying the origin and evolution of the planets.

The cosmic dust curator has always had a passion for exotic rocks and minerals. “I knew what I wanted to study by the time I was eight,” Zolensky says. By the time he was nine, his rock collection filled his bedroom and his family’s basement. “My parents didn’t mind,” he claims, “as long as I was serious about becoming a mineralogist.” Zolensky still

keeps rocks everywhere: on bookshelves in his office and throughout his house. “When I moved to Johnson Space Center from Penn State, my household goods consisted of a ton and a half of rocks and books, and only 500 pounds of everything else,” he says. “The movers couldn’t believe it. But rocks are like old friends to me—you never know when you’ll need them.”

He found one such friend on a field trip to the Old Cornwall mine in Pennsylvania in 1979, shortly before finishing his doctorate in mineralogy. “It’s a very old mine,” Zolensky explains. “Materials for Revolutionary War bullets were mined there.” Another student pointed out what looked like hair growing on a rock, which turned out to be an obscure mineral called tochilinite. Zolensky stashed a sample in his collection, where it remained until 1983. Then he read about an important mineral found in meteorites, layered like mica but curled like a roll of paper towels. Meteorite specialists didn’t know what it was, but Zolensky immediately realized the mineral was tochilinite and retrieved his hairy rock from the closet.

His pack rat instinct had paid off. “The Cornwall mine was closed shortly after our field trip,” Zolensky says, “and the outcropping of tochilinite is now far underwater, impossible to reach.”

Since then, Zolensky has turned his attention from underground mines to the heavens. Most of the cosmic dust Zolensky studies is gathered by ER-2 aircraft—a variation of the Lockheed U-2—on research and photo missions in the stratosphere. Mounted under the wings of the airplanes are 2½-inch-square plexiglass plates coated with silicone oil that trap dust drifting at altitudes between 50,000 and 80,000 feet. Most cosmic dust particles range from 1 to 12 microns across, smaller than the

David Nance



*Within the lab, cosmic dust is stored somewhat unceremoniously in Tupperware-like containers.*



width of a human hair. Larger pieces burn up upon entering Earth's atmosphere, and smaller ones escape the collectors. Toward the end of each flight the plates are retracted into airtight containers. After 20 hours of exposure, spread over several flights, the plates and their cosmic cargo are sent to Zolensky's lab.

The stratosphere is not the only

source of Zolensky's specimens. Particles have been drifting to Earth for billions of years. "Chinese scientists recently discovered extraterrestrial iron silicides in meteorite spheres they collected from the sea floor," Zolensky says. Last year, his search for extraterrestrial material on the ground led him to Antarctica, where he collected samples of 100,000-year-old ice. He's found

*A mineralogist by training, Zolensky's first love is rocks—in fact, his earthly possessions consist mainly of rocks and books (above).*

*Examined through a scanning electron microscope, this sample's fluffy, porous appearance (right) reveals its probable origins: a comet.*

particles within the ice samples that definitely were not formed anywhere on Earth, and he suspects that some may predate the birth of our sun.

However distant their origins or points of collection, all Zolensky's particles eventually put in their time in the Houston lab. In the 1970s, the laboratory was used to process moon rocks. In 1981 it was modified and made ultra-clean to process cosmic dust. There are now fewer than 100 microscopic grains of dust per cubic yard of air—"about a couple of grains per room," says Zolensky—making it one of the cleanest rooms on Earth. Lab workers with allergies find instant relief here from Houston's high pollen count. ("I ought to charge admission," jokes Zolensky.)

To maintain this environment, elaborate precautions are taken. After pass-

ing through a security atrium, lab visitors and personnel come to a locker room. Here they don lint-free white suits, which cover everything from neck to ankles, and hoods, which cover the entire head and face except for the eyes and nose. Once properly attired, they walk down a small corridor lined with fans (to blow off contamination) and through a storage room before reaching the lab proper. Within the lab, two huge low-velocity laminar-flow fans blow in filtered air to push any remaining contamination toward the storage room.

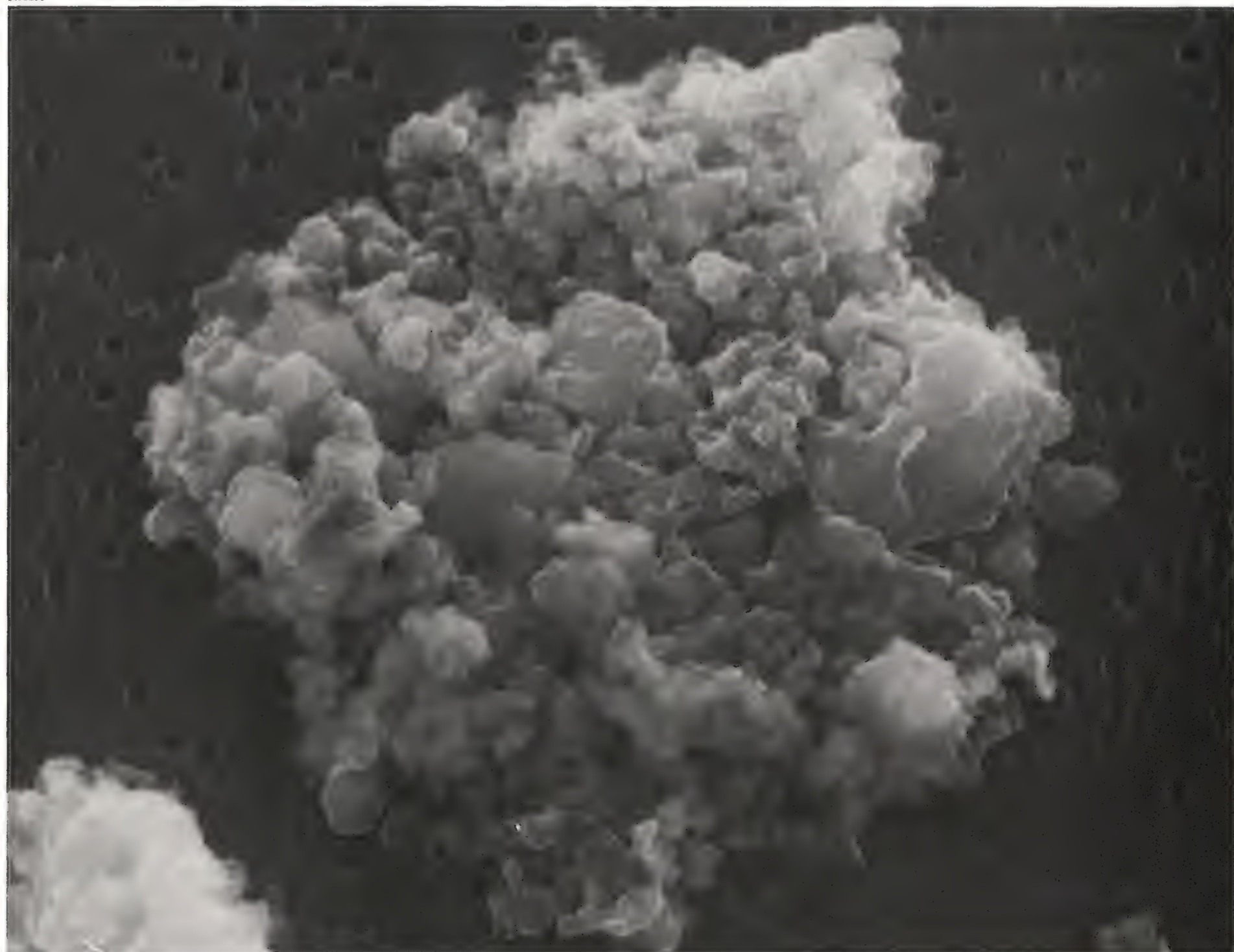
All processing of cosmic dust is done on tables set against the cleanest wall of the room, the one next to the fans. The workers remove particles from the plates, study their composition, then photograph and catalog them. The particles are then stored until they are re-

quested by university research groups.

You'd almost expect that these mineralogical rarities would be displayed like the Hope Diamond at the Smithsonian's Museum of Natural History. Instead, the dust collection is divided among six rectangular Tupperware-like containers stacked unceremoniously in the corner of a nitrogen-filled cabinet the size of a hospital incubator.

"Some of what we get turns out to be manmade debris, such as rocket propellant," says Zolensky. "However, cosmic dust is so unlike anything created on Earth that it's usually easy to tell it apart." Dust from comets is fluffy, porous, and black with carbon. Particles from meteorites may be brown or orange with flecks of green, the colors of iron and magnesium silicates. These minerals are common in asteroids, from

NASA



which meteorites are born. Rocket propellant is almost always easily distinguished by the aluminum oxide spheres it contains.

The laboratory may even possess a few specks of dust that were formed in another solar system. "We haven't positively identified any interstellar dust yet," says Zolensky, "but I suspect it would consist of calcium, aluminum, titanium oxides, and silicates—minerals very resistant to heating."

Zolensky has found some cosmic dust particles rich in these minerals and has sent them to physicist Kevin McKeegan at Washington University in St. Louis for examination by a device called an ion probe. The probe measures various isotopes in the particles and detects elements that occur rarely or not at all on Earth. "We hope to see radically different characteristics to convince people that these particles are interstellar. We haven't seen that yet," says McKeegan. "So far, the isotopic contents prove that

three out of four particles Zolensky has sent me are definitely extraterrestrial, but they're probably not interstellar—most likely they formed within the solar system."

Ultimately, cosmic dust particles may help determine the origins of life on Earth. Scientists at the NASA Ames Research Center in California have hypothesized that life formation was linked to the presence of clay minerals in the solar system, and that these clay minerals may have been borne to Earth on comets and meteorites. If so, some of the particles in Zolensky's collection may contain these primitive clays.

Mineralogist Frans Rietmeijer, a former neighbor and sometime lab partner of Zolensky's, now at the University of New Mexico, uses electron microscopes to examine cosmic dust. If clay minerals were indeed prevalent in early meteorites, Rietmeijer would probably find them among the samples from Zolensky's lab. The evidence is still far from conclusive, but the search is an intriguing one. And Rietmeijer seems to enjoy Zolensky's company: while the two were neighbors, they often shared barbecue sauce and cosmic theories at

dinner. "When we get together, we can discuss the whole universe by midnight," says Rietmeijer.

While Zolensky diligently catalogs and disseminates particles from the past, he also plans for the future. His greatest fantasy is to collect rocks on Mars. Short of that, he'd like to participate in a comet sampling mission, in which a chunk of a short-period comet—one that returns to Earth's vicinity every few years—would be brought back for study.

But this year, he's settling for collector plates 10 times bigger than the current ones to pick up more cosmic dust. And he looks forward to the day when collectors will be mounted on the proposed space station to capture cosmic dust drifting 250 miles above Earth.

Someday, Zolensky would like to settle in New Mexico, where he studied for his bachelor of science degree. At home with timelessness, he loves to wander through the deserts and mountains, where fossils, rocks, and shards from ancient Indian civilizations are uncovered by the constant winds—remnants of a more easily deciphered history for the Curator of Cosmic Dust to study. ➤

*Kevin McKeegan uses an ion probe to examine cosmic dust for evidence of interstellar origins.*

Peter Zimmerman



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### The Happy Landing

It's not easy to be a hero these days. Not only do you have to perform some superhuman deed, you have to do it with great aplomb as the world watches, judges, and criticizes. Then, once the deed is done, you are expected to be witty, charming, and urbane on an endless round of talk shows.

You are supposed to be able to sum up your goals and aspirations, your motivation and accomplishment, in one original, quotable sentence, something along the lines of "One small step for man . . .," something for the media to ponder, something for children to remember as long as they live.

Dick Rutan and Jeana Yeager were as well prepared for their record-setting *Voyager* flight as they could have been, but they never took a "How to be a hero" class. When *Voyager* landed on the morning of December 23, 1986, Rutan and Yeager couldn't live up to public expectations.

After *Voyager* touched down at Edwards Air Force Base in California, Dick and Jeana pulled themselves out of the cockpit and sat on the aircraft for a few minutes to get their "land legs." The world watched and waited. I expected to see them at least leap through the air with joy or stamp their feet

on the desert ground. I thought that perhaps one or both of them would drop to their knees and kiss the earth. But they just sat. Finally a cameraman shouted, "Wave or something."

Otherwise, *Voyager's* round-the-world flight was a publicist's dream. From the takeoff up until the very last hours, one life-threatening catastrophe after another plagued the crew. For nine days we listened anxiously for the latest reports. We took to talking about Dick and Jeana as though they were old friends. And as *Voyager* passed the halfway mark, more and more of us became convinced they would make it.

Late Sunday night I packed my car and headed for Edwards Air Force Base, the theme from *Rocky* playing in my mind. If Dick and Jeana could spend nine agonizing days in the air to make history, I could spend nine hours on the freeway battling 18-wheelers to be there when they did.

By Monday morning, *Voyager* had just crossed Central America. On the way to the landing site I stopped at Mojave Airport, *Voyager's* base of operations 20 miles northwest of Edwards. The *Voyager* gift shop was doing a jumping business.

Shoppers were snapping up *Voyager* T-shirts, *Voyager* caps, and *Voyager* "shakes" and soup.

The press was in a frenzy of its own, hungry for the smallest shred of news or a fresh angle on the story. One reporter asked Jeana's sister if Jeana had wanted to fly nonstop around the world ever since she was a little girl, as if dreams belonged to the young alone. It was good to hear that she hadn't; there was still hope for the rest of us. Two reporters wanted to know if a cat lingering near the hangar belonged to Dick and Jeana. I could just hear the bulletin: "Lonely *Voyager* kitty anxiously awaits owners' return. News at eleven." But the cat was a stray. No story there.

If the media seemed uninformed, it wasn't entirely their fault. Aviation aficionados probably had been following *Voyager's* progress since the moment it advanced beyond a concept sketched on a napkin. But to the rest of the world, *Voyager* was virgin territory. Even during the flight, *Voyager* mission control issued no official press releases reporting the aircraft's latest position. There were no fact sheets listing all the details enquiring minds wanted to know, such as the nature of Dick and Jeana's relationship.

As the flight neared an end late Monday, I moved south to Edwards Air Force Base. Air Force officials roped off separate areas for the press and the public at the dry-lake-bed landing site, putting the media closer to where the action would be. The television networks laid down power lines and telephone cables near the site and marked off their territories with vans and trucks. Officials made sure all the network people could get equally good shots. Everyone else had to scramble around them for a vantage point.

Photographers who couldn't, or wouldn't, spend the night at the site claimed their territory with strips of tape stuck to the ropes or on the desert floor. But these displays meant nothing to the drivers of the trailers that rumbled in during the night and parked wherever they wanted.

As landing day dawned, the temperature dropped. Representatives of corporations

*We wanted heroes—what we got were two tired pilots.*

Photographs by Mark Greenberg/Visions



that had helped sponsor the flight started courting the press with doughnuts and coffee and seats inside their nice warm trailers. A newspaper reporter tried to look interested in a discourse on the unique characteristics of Hercules carbon fiber while she munched on a Hercules sweet roll at four in the morning.

By 5:30 the crowd became a rumor mill. "An accident in the cockpit caused a fuel spill." "They're looking for fuel they know they have, but they can't figure out which tank it's in." "They'll land with two gallons of fuel left." "It's touch and go whether they'll land at all."

By 6:30 the sun started to lighten the sky and the temperature took one last plunge. We picked up the Edwards air traffic control tower's frequency on our radio, and at 7:10 we heard a controller tell *Voyager*, "There are scattered clouds at 8,000 feet." At 7:20 they were 28 miles out—about 13 minutes to go.

At last the trailers went quiet. We could hear Dick chatting with the chase plane pilots and the controllers: "All we've got to do is land this thing and it's in the bag, I guess." I was still waiting for that one memorable line, the one that would send a chill up my spine forever. That wasn't it.

At 7:30 the tower had *Voyager* in sight and Dick announced, "I'll be there as soon as I can." A photographer standing next to me said, "There they are." I scanned the southern sky with my binoculars and found *Voyager* approaching with three chase planes, like an eagle escorted by three sparrows.

My hands started to shake. My eyes filled with tears, and I couldn't keep the airplanes in sight. I had to fight off a sob that was welling in my throat.

Maybe, as some have dared to say, the flight of *Voyager* will have no effect on the future of aviation. Maybe Dick and Jeana will fall into obscurity like countless others in the record books. It was a tough week for grabbing headlines; they were competing with the Iran arms scandal. And the fuel efficiency and brilliant engineering that made *Voyager* work just can't capture the imagination these days like the raw power portrayed in the movie *Top Gun*.

Still, I have that one moment that will stay with me forever. A moment uncluttered by the patter of broadcast journalists trying to make sense of events they didn't understand. It didn't matter that neither Dick nor Jeana could come up with a single inspiring sentence. What did matter was that they dared to try it, and then—battered and bruised, tired and depressed—succeeded.

For a brief moment on the morning of December 23, the event unfolding in the



*Enthusiasts and cynics alike cheered Voyager's accomplishment.*

California desert elated me. Cynicism was replaced by inspiration. When *Voyager* came into view, a tiny spot in the wide desert sky, I felt the spirit that lives in all of our hearts. It's the spirit that was conveyed

by a small, hand-painted sign that appeared at Mojave Airport the day before the landing. "VOYAGER," it said, "YES YOU CAN."

—Elaine de Man

## How We Built Slim's 60-Day Wonder

In 1927 the race to make the first nonstop flight between New York and Paris shifted into high gear, with fliers from both America and Europe lured by the glory that would accompany the feat. They were also attracted by the Orteig Prize, a \$25,000 award originally offered in 1919 by New York hotel owner Raymond Orteig. A native of France, Orteig had hoped to improve the link between his native and adopted countries by increasing interest in the unprecedented flight.

While no one had flown all the way from New York to Paris, the Atlantic had been crossed by air before. In May 1919 Lieutenant Walter Hinton and five crew members took their Curtiss NC-4 flying boat from Newfoundland to Portugal, via the Azores and England. In June of that year, John Alcock and Arthur Whitten Brown made the first nonstop crossing of the Atlantic, flying their Vickers Vimy bomber from St. John's, Newfoundland, to a rough landing in a peat bog outside Clifden, Ireland. Crossings were later made by airships and the world cruisers Chicago and New Orleans. Aviators also made successful crossings of the south Atlantic in 1926 and 1927.

But the long flight between New York

and Paris ignited the most public interest, and by 1927 improved aviation technology, especially engines, had attracted several heavyweight challengers. The U.S. Navy's Lieutenant Commander Richard E. Byrd, the first man to fly over the North Pole, was aiming for the Orteig Prize, as were René Fonck, the highest ranking allied ace of World War I, stunt flier Clarence Chamberlin, Frenchmen Charles Nungesser and François Coli, and Noel Davis and Stanton Wooster, two Naval Reserve officers from Massachusetts.

Then there was the dark horse candidate, a former barnstormer, airmail pilot, and Air Corps Reserve lieutenant named Charles Lindbergh. The 25-year-old pilot, soft-spoken but determined, had decided during an airmail flight that he could make the risky 3,600-mile flight. With the backing of a group of St. Louis businessmen, Lindbergh set out to fund the construction of an airplane. Unlike the other challengers, he planned to make the flight alone, in a single-engine aircraft.

In the following account, which appeared originally in *True* magazine in 1957, Harm Jon van der Linde recalled the production of Lindbergh's airplane, the Spirit of St. Louis. The chief mechanic for

the Ryan Airlines flight line, van der Linde was in a unique position to witness the construction as the race for the Orteig Prize entered its final weeks.

By the 15th of February, 1927, four aircraft manufacturers had slammed their doors in the face of Charles A. Lindbergh. For one reason or another, Fokker, Wright, Travel Air, and Bellanca had refused to sell him the airplane he needed to enter the New York-to-Paris race. He had just about reached the end of his rope when he decided to send a wire to us—a practically brand-new company, Ryan Airlines, Inc.

What Lindbergh wanted was a single-engine monoplane that could fly a record nonstop distance of 4,000 miles, and he wanted it finished in three months—on a budget of only \$15,000.

We'd just been in business for a few years, and our only factory was an abandoned fish cannery out on Juniper, a waterfront street in San Diego. But nothing fazed B.F. Mahoney, the young sportsman who had just bought Ryan. He sent a telegram right back telling Lindbergh that we could build his plane in two months, not three, and asking him please to send us a 50 percent deposit.

So a week later, on February 23, a slim, baby-faced young man knocked on the cannery door and stepped into the dusty little hole-in-the-wall we called our office. Stiffly but firmly, he shook hands with Mahoney, Walt Locke, our purchasing agent, and Don Hall, our new engineer. "Hall has been making some preliminary sketches," Mahoney said. "We think we can build it, all right."

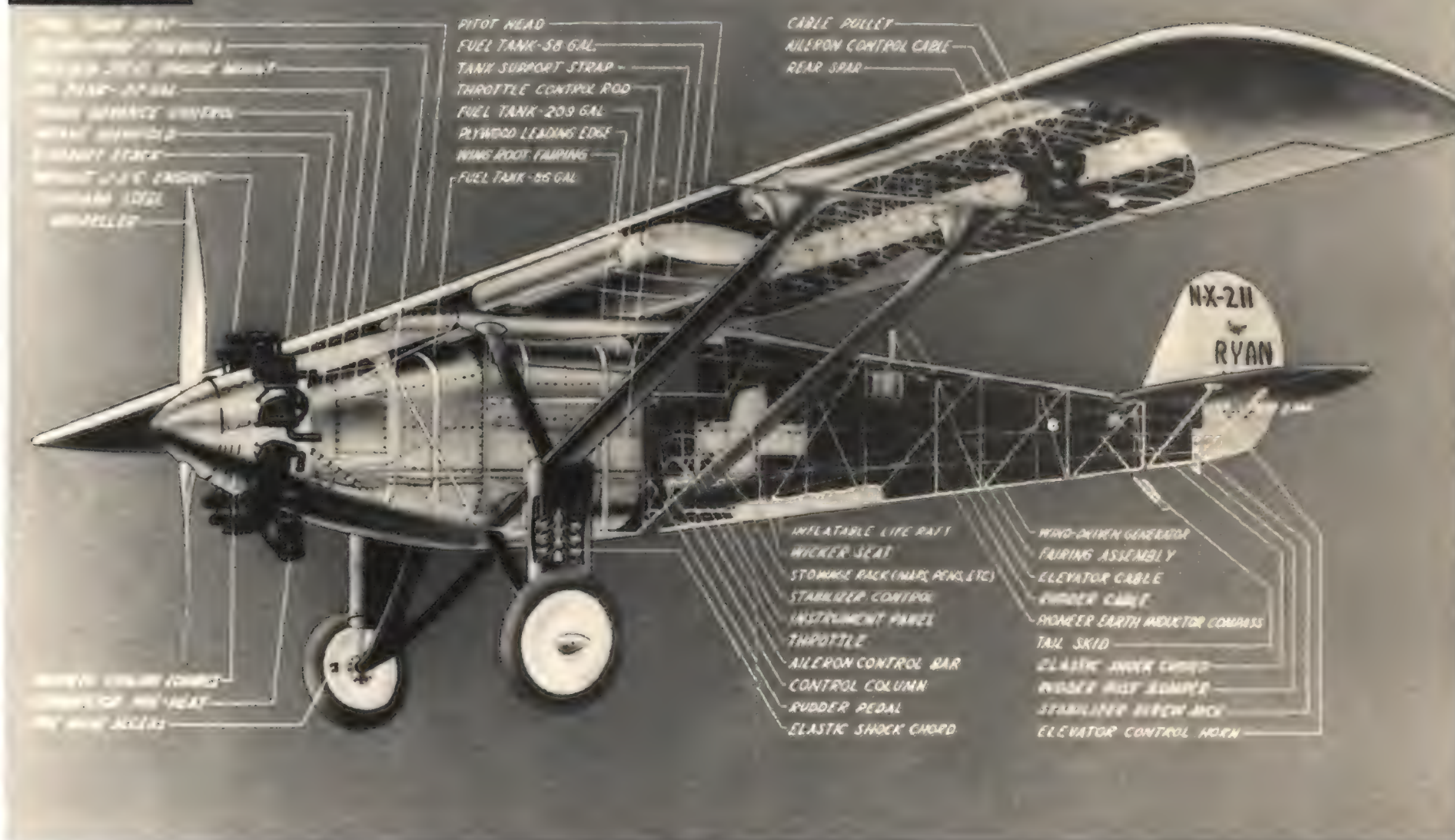
Lindbergh looked around at the dusty office, at the single bulb hanging from a cord attached to the unfinished ceiling, at the fish scales that still stuck to the floor. Mahoney grinned. "I know it doesn't look like much, but we just moved in. We've got another shop out at Dutch Flats where we do our final fitting and flight tests. Come on, I'll show you around."

Still looking somewhat dubious, Lindbergh trailed Mahoney, Locke, and Hall out into the shop and up the stairs.

After completion, the Spirit of St. Louis was still a continent away from the Atlantic.



NASM

AERO DIGEST  
CUTAWAY

Other Orteig Prize competitors had multi-engine airplanes. Lindbergh insisted that one engine provided the best chance for success.

Up in the loft, five men and three women were working on three Ryan Bluebirds, the five-passenger planes we used on our small San Diego-to-Los Angeles airline. Mahoney, talking fast to try and overcome Lindbergh's obvious disappointment over our crude facilities, introduced him around the shop—making each of us sound like the leading expert in the field. I'm sure that Lindbergh barely heard the names. He was walking slowly around the dusty, cobweb-filled loft, running his fingers along a curving wooden wing rib, tapping the doped-cotton finish of an aileron.

Mahoney's brash voice broke the awkward silence. "Now that you've met us, why don't you and Hall sit down and work out a preliminary design? Then we can talk business."

Lindbergh nodded, then slowly trailed the apprehensive group back through the dingy loft. Back in Hall's drafting room, Lindbergh laid down his specifications for his plane—it must be a monoplane with a single, air-cooled engine, and it must have a range of 4,000 miles. To young Don Hall, who had to put together a ship that would

fit those specifications, the young flier sounded a trifle insane. No plane—not even the biggest multi-engine bomber—had ever flown so far.

Hall had originally hoped that he could do the job by merely souping up our Bluebird, but his first rough performance curves told him that the Bluebird would have to be completely revamped. Lindbergh would need what amounted to a flying gas tank—a plane that could carry at least 425 gallons of fuel.

Working quickly, Hall doubled the Bluebird's takeoff gross weight to 5,135 pounds. He increased the wingspan from 36 to 46 feet. That meant changing every wing member but the ribs.

For better stability, the tail was moved aft 24 inches, and then, because Lindbergh insisted that the center of gravity be far forward in case he had to crash land, the engine was moved forward 18 inches. That meant an all-new fuselage. A wider wheel tread was needed, so new landing gear had to be designed.

Eighteen hours after he sat down, Hall knew roughly what it would take to build

the plane Lindbergh wanted. He pulled his pile of papers together and went to Mahoney.

Mahoney, new himself in the aviation game, looked at the figures and then at his green young engineer. "Can we do it?"

Hall faltered. "I think so."

"In sixty days?"

"If—if the men put in a lot of overtime."

"All right, let's get under way."

With those words, B.F. Mahoney committed Ryan Airlines to its part in the biggest and most daring gamble in the history of aviation.

While Hall sweated over his drawing board, Lindbergh, needing to get the feel of our Bluebird, came down to the flying field at Dutch Flats. I'm factory manager of Ryan Aeronautical Co. today, but I was a chief mechanic on the flight line at that time. And that's where I met him.

Red Harrigan, our chief pilot, had asked me to warm up a plane. I didn't know who it was for, so when I saw this lanky boy getting in, I ran back to Red and asked him if it was all right.

Red said, "Yeah." And we watched the

kid take off. He turned back over the field and wrung out that plane for an hour. I looked at Red and he looked at me.

Pilots are funny sometimes. They seem to have a strain of tension deep inside them. I've heard it said that many of them like to fly to get away from the earth, from people who say and do things that wind them up tighter inside.

They cover their tension in different ways. Sometimes by drinking hard and raising hell. Sometimes by drawing within themselves except for rare outbursts. Lindbergh was the quiet type.

I met him at the flight line when he taxied in from that first flight. "Nice flying," I said.

He barely nodded as he walked away.

But being wrapped up in himself didn't mean that he wouldn't speak out when he had a mind to. Our engine installation mechanic found that out later when he was helping to install the engine in the fuselage. The job was pretty well finished when someone dropped a 10-inch crescent wrench onto the no. 1 cylinder.

Without a word, Lindbergh raced over to look. A piece the size of a quarter had been chipped out of one of the cooling fins. The mechanic said, "We can smooth that out with a file and paint it and no one would ever know the difference."

"I'd know the difference," Lindbergh snapped. Then he turned to Hawley Bowlus, our production chief. "We'll have to put in another engine."

Someone in back muttered: "Why does this damned plane have to be so perfect?"

Lindbergh turned to look at him.

"Because I'm a damn poor swimmer, that's why."

It's not surprising that the men were grumbling. They were only getting 65 cents an hour, and they were doing their job as well as they could. And then suddenly this tall, silent stranger walked in and started peering over their shoulders and checking every move they made. No one else had ever watched over the production of a plane that way. And certainly no one had ever been so fussy about details.

Take the oil lines, for instance. In those days, you couldn't just draw a pre-cut, pre-formed oil line out of the stock room and install it. We drew out maybe 25 feet of straight copper tubing and then cut it right at our benches and beaded it and strung it to fit. And we weren't working from complete plans, either. We made only a few blueprints—mostly just shop sketches—because we didn't have time.

Anyway, we were cutting and fitting oil lines one day when Lindbergh came up. He was wearing the same baggy blue suit and same battered hat. He stood behind me for a few minutes, rocking back and forth on his heels and whistling—only he never made any noise. The air just came out soft. Then he said, "Don't make any oil line more than 18 inches long without a joint and a hose connection."

I nearly dropped my pliers. "What?"

Lindbergh said, "Break the oil lines every 18 inches and reconnect them with rubber hose."

"What for?" I asked.

"Well," said Lindbergh, "most forced landings I've heard about on long hops were caused by a break in the oil line. From vibration."

So we went back to work. We cut the lines every 18 inches and put on an "olive,"

a piece of tubing that's tapered at each end, in the line at every break, put rubber hose over that, and clamped each end of the hose.

By the next week, the guys had begun to take their gripes out on Hall. They'd bitched plenty when he told them they'd have to hold their work to 1/32-inch tolerance. No one had ever drawn the line that fine in building an airplane before.

We all resented [Lindbergh's] probing and his curtness when he talked to us. But at the same time, we grudgingly respected his single-minded fight for perfection. At first, it had made only a bad impression. But then we began to believe that it just might give him an edge over the others.

By April 1, the fuselage was complete, but Ryan and Mahoney could see that we weren't going to finish on time at that rate. From then on the whole crew began working nights. But there wasn't much grumbling anymore, even when Lindbergh walked in and tore up two days' work. His zeal was rubbing off on the men and they were warming up to him. In fact, a kind of bond began to grow between them that has never been broken to this day.

But the long hours, seven days a week, began to tell. By the middle of April, [Fred] Magula walked up to Bowlus and told him, "That blasted fuel tank is ready." It took nine of us to lower it carefully into place. Magula had pushed and pounded that terneplate so precisely that the big 200-gallon tank cleared the sides of the fuselage by only an eighth of an inch.

The tempo of construction was increasing and we were all caught up in it. We wanted to be a part of this plane that would tempt destiny on the long flight to

*Since most of his journey would be over water, Lindbergh, a poor swimmer, demanded a perfect airplane.*

NASM



Paris. A bit sheepishly, we signed our names on the front wing spar, and, for good measure, we also wrote them inside the prop spinner.

Still Lindbergh refused to relax his standards. We were installing the engine controls one day when he stopped by to watch us. He whistled soundlessly for a long time, then reached in to test the "give" in one of the cables that ran from the carburetor to the cockpit. He shook his head. "We've got to take that out," he said. "There's not enough clearance between the tube and the wire."

At Ryan we rigged all our controls on the "sliding music wire" principle. That is, the mechanical connection between the throttle and the carburetor was a piece of music wire that slid in a copper tube. Lindbergh was afraid that the tube would pinch the wire where we brazed the fittings.

So we ripped out all the controls and formed new ones with 5/16-inch tubing instead of 1/4 inch.

On April 26 we hit the home stretch. The shop was electric. There was no chatter now. Everyone talked in low voices. Lunches were forgotten until 3 and 4 in the afternoon. Most of us thought, "He can't miss now."

But some of the men were skeptical. And that day we learned they had a right to be. Davis and Wooster died in a crash near Langley Field. Just like that—their transatlantic plane, fully loaded, spun into a marsh from a normal cruise.

But the next day, we finished. Like the man who built the boat in his basement too big to get it through the door, we'd forgotten that this wing was 10 feet longer than the usual M-2 wing. We couldn't get it down the stairs.

So we took off the doors, pushed a box car along the railroad tracks next to the building, and slid the wing out on top of the box car. Then we hauled up a borrowed derrick and lowered it onto the wing dolly.

On April 28, exactly 60 days from the time business formalities were completed, the *Spirit of St. Louis* was ready for its first test flight.

Everyone came out of the shops and the offices to see it fly. They were like kids let out of school for a parade. They cheered as I stepped up to pull through the big metal prop.

She caught on the first pull and Lindbergh, grinning, slowly nursed her to full power. He signaled "chocks away" and Doug Corrigan, a young man who later flew the Atlantic himself, darted under her broad wing to pull out the chocks.

Lindbergh poured on the coal slowly, then hauled her off the ground, and the *Spirit of St. Louis* was airborne.

NASM



*Curious crowds greeted Lindbergh and his airplane on a post-flight goodwill tour.*

But no plane is finished until it has been completely tested. After several short test flights during the next few days, Lindbergh was satisfied on May 4 that the *Spirit of St. Louis* was ready for the biggest test of all. He flew it to the Camp Kearney parade ground, the longest, smoothest stretch of field available, and we began filling the big center gas tank for load tests.

I climbed up onto the fuselage with a small funnel in one hand and a five-gallon can in the other. I balanced myself on the top and hand-poured the gasoline slowly through a chamois in the funnel. My arms ached. My head swam from the fumes. But it was the only way we could gas her up.

Lindbergh made 10-minute flights with 38, 71, 110, and 150 gallons aboard. After each flight, I climbed back up on the fuselage and slowly poured in 50 more gallons of gas. It took almost an hour each time because the air couldn't bubble up through the filler neck fast enough.

So we loaded her up to 200, then 250, then 300 gallons. And then we had to stop. Lindbergh wanted to test her further, at 50-gallon increments all the way to 425 gallons. But on the 300-gallon test, the wheel bearings smoked, the tail skid broke, and the shock absorbers hit bottom.

But Lindbergh wasn't discouraged. "I think she'll be okay," he said. "We're at 500-foot elevation here, and I'll be taking off for the flight at sea level. And I can take it easier getting her started there—

Roosevelt Field has almost a mile of runway. Let's just beef up the landing gear a bit, and I think she'll get off the ground with 425 gallons."

That shows how close he was figuring this. He had figured the length of the runway, and he'd even taken the differences in air density between 500 feet and sea level into consideration. I'll bet he shaved before he left just to cut down on the weight.

Just one more change after that. Lindbergh insisted that we rip out one of the oil lines that ran close to the engine and tie in a three-turn coil to absorb engine vibration.

Then, on the afternoon of May 10, after waiting two days for good weather, he was ready. He shook hands with every man and woman in the company.

"Send us a wire when you get to Paris," someone said. He grinned and nodded. At 3:55 p.m. Pacific Time, he eased her off the ground and headed east. Hall, Bowlus, Harrigan, and I chased him as far as the Laguna Mountains in a Bluebird. We dipped our wings as we turned away and the *Spirit of St. Louis* droned straight on toward the east.

*Excerpted from "How We Built Slim's 60-Day Wonder" by J.J. van der Linde, as told to Eliot Tozer, from True, April 1957. Reprinted with permission of CBS Magazines.*



Mon.



Tues.



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## Reviews(&Previews

**Challenger: A Major Malfunction.** By Malcolm McConnell. Doubleday & Company, 1987. 260 pp., b&w photographs, \$17.95 (hardbound).

**Prescription for Disaster: From the Glory of Apollo to the Betrayal of the Shuttle.** By Joseph J. Trento, with reporting and editing by Susan B. Trento. Crown Publishers, 1987. 288 pp., b&w photographs, \$18.95 (hardbound).

Reading these books, one cannot help wondering: Why didn't anybody ask these questions or tell these stories *before* January 28, 1986? It's sad to think that these depressing, sometimes shocking revelations did not rate as news until after *Challenger* blew up.

*Challenger: A Major Malfunction* retells the story of the events leading up to the accident in much the way the Presidential Commission on the Space Shuttle Accident (the Rogers Commission) uncovered it, step by careful step. But Malcolm McConnell has added depth to the narrative with telling portraits of key officials at the National Aeronautics and Space Administration and its top contractors; reconstructed conversations among *Challenger* astronauts and their families and friends, and among NASA officials, in the days preceding the accident; and reflections on press coverage of the shuttle program. His profile of the domineering former director of NASA's Marshall Space Flight Center, William Lucas, is downright scary. And he dutifully notes that many veteran space reporters, himself included (he's covered the space program for *Reader's Digest*), had been dazzled by manned space flight and lulled over the years into an unquestioning acceptance of whatever NASA told them.

McConnell tells his tale well. He manages to build suspense as he unravels a mystery that's already been solved. Anyone who followed the Rogers Commission hearings will remember the awful sinking feeling that grew stronger as the story unfolded; reading this book has the same effect. McConnell heightens the drama by



interweaving crucial steps toward the decision on launch with mundane details such as the gathering of astronauts and their families to watch the 1986 Super Bowl on Sunday, January 26.

Problems festering at NASA for years are outlined: the bitter rivalries among NASA field centers, the ease with which a select group of men moved between NASA and NASA's top contractors, the struggle to maintain a healthy budget. And McConnell explores the political battles over space shuttle plans and NASA's deliberate overselling of the experimental shuttle system as an operational "space truck" to maintain funding.

But all these problems were apparent before the accident. Why wasn't anyone interested? Maybe it was because bureaucratic infighting and fudging of budgets and schedules are not news; an explosion that kills seven people is.

The book would have been better off without the lengthy discussion of whether the White House pressured NASA for a *Challenger* launch on January 28, the day President Reagan planned to give his 1986

State of the Union address, or whether NASA pressured the White House for a mention of the *Challenger* launch in the address. This part of the story rests on thin ice. Overall, though, McConnell's story rings true and reads well—for instance, his step-by-step explanation of the rupture of the solid-rocket booster seals and the explosion of the orbiter is absorbing, even though most space-watchers now know it by heart.

Unfortunately, the book is flawed by a complete lack of references. There are no footnotes, no bibliography, absolutely no indication of the sources for any of this information. And McConnell closes with an off-the-mark evaluation of the space program's future: "Space business . . . will never return to the Emperor's New Clothes mentality that prevailed until January 28, 1986 . . . . After the accident, a new, saner space policy was emerging." But in fact, as of the spring of 1987, NASA's major new project, the space station, is plagued with management and funding problems, the agency is in the process of reorganization, and U.S. space policy is still in disarray.

Only the last 20 pages of *Prescription for Disaster* are devoted explicitly to *Challenger's* demise. What Joseph and Susan Trento set out to do is trace the roots of the accident by following the inside story of the rise and fall of the space program over the last 30 years.

The Trentos are well qualified for this sort of research and coverage: Joseph Trento is a reporter for Cable News Network and his wife Susan a former staff member of a congressional space subcommittee. They interviewed key government and industry officials, present and former, and let these outspoken people tell much of the story themselves. The result is a gripping and gossipy text. It's too bad that this valuable piece of investigative journalism is not a great piece of writing: the book reads like a collection of notes hurriedly strung together. The haphazard presentation is full of interesting tidbits of space history that deserve more thorough explanations (the Blue Gemini and Dyna Soar projects, for example).

But the book is brimming with scandalous stories—of petty spats, serious power struggles, rule-bending, and suspiciously close NASA-contractor relationships—that will appeal to space groupies and political junkies. It begins to reveal how the NASA of the grand Apollo days had changed into quite a different animal by the era of the shuttle.

The Trentos air some of the aerospace industry's dirty laundry, telling tales of shady business dealings that have been made public before but didn't draw much attention at the time.

There's the story of the "cola wars," touched off when both Coca-Cola and Pepsi-Cola asked to fly zero-G soft drink cans on the shuttle. Former NASA administrator James Beggs recalls: "Of all the things that were done on the shuttle, the one that caused the most aggravation was the goddamn cola wars." Beggs told the Trentos that lobbyist Michael Deaver, a former advisor to President Reagan, bugged him regularly during the war to get Pepsi out of the way of his client, Coke.

Then there's former Reagan administration science advisor George Keyworth's opinion of some of his colleagues: former astronaut and U.S. senator Harrison Schmitt "is a flake"; former National Security Council director of space programs Gilbert Rye is "a thug, an absolute thug." Describing NASA, Keyworth says, "Of all the organizations that I have dealt with . . . I have only seen one that has lied. It was NASA. From the top to the bottom they lied . . ."

With all the awful revelations preceding the Trentos' account of the accident, the loss of *Challenger* seems almost anticlimactic. They end their book in a minor key: "The cast of characters who assisted [NASA administrator James] Fletcher in bringing us the broken promises of the shuttle is being reassembled in Washington."

This is true. Perhaps Malcolm McConnell and others should take another look at the "new" NASA and the White House space policy machine.

—Linda Billings

#### Letters from a World War I Aviator.

By Josiah P. Rowe Jr. Collected and edited by Genevieve Bailey Rowe and Diana Rowe Doran. The Sinclair Press, 1986. 151 pp., b&w photographs, \$15.95 (hardbound). Available by order from The Sinclair Press, 42 Bay View Road, Wellesley, MA 02181.

*Letters from a World War I Aviator* is a

wonderful look at the day-to-day life of Josiah P. Rowe, a lieutenant in the U.S. Army Air Service. With 11,000 fellow Americans, Rowe trained to fly in "the Great War."

What sets this book apart from other World War I memoirs is that Rowe was one of only about 600 U.S. aviators who actually flew combat missions in France. That Rowe flew only three missions over the front dramatizes just how unprepared the United States was for air war when it entered the European conflict on April 6, 1917. This is brought out time and again in the young Virginian's letters describing to his friends and family his adventures "over there."

The phrase "over there" may bring to mind images of the mud and blood of northern France—but the reader will be just as surprised as Rowe was to find that, after a treacherous journey across the U-boat-infested Atlantic and two days in Paris, his training squadron was to spend the next seven months learning to fly at the famed Foggia Instruction Center in Italy. This historical accident makes Rowe's writings all the more significant, since most World War I literature to date has focused on the fighting in France and Belgium. Ernest Hemingway's romantic *A Farewell to Arms* has for decades stood alone as the only widely read description of the Italian front.

Rowe's talents as a writer make his book a good companion to Hemingway's classic. Rowe details the daily routine of the American aviators: the comedy of being taught to fly by instructors whose knowledge of English is, at best, limited; the somber sight of starving children begging for food on the streets of Foggia.

While Rowe's weekend outings to swim off Capri or day trips to the opera in Naples provide the young lieutenant with good entertainment, one becomes increasingly sympathetic to his yearning to fly in combat. In a later letter to his mother he

exclaims, "Gee! But it was awful to languish in camp down there for endless days and weeks with little to look forward to but more of the same, when other fellows were getting promotions, medals and Germans." But just as his frustration becomes unbearable, Rowe receives word that he is going to France. By this time readers are ready to cheer along with him.

Rowe is kept busy once he arrives in France in July 1918. His letters become more sporadic, and they take on a more serious—and more overtly patriotic—tone.

The United States is in the war full swing by this time. "As we went deeper into the heart of the country we began to see ever increasing signs of America's participation. More and more soldiers, American locomotives, American supplies on the trains, American cigarette boxes along the tracks, and American slang around the stations," Rowe writes. "At one station there was an American canteen operated by good-looking American girls where they served WHITE bread and coffee. Honestly, it tasted like cake to us. Nothing but our bashfulness prevented us from falling on their necks both for the bread and for their own sweet selves."

Once Rowe settles down, he finds out that in order to fly combat missions over France, he must first train in France. The would-be warrior suspects, if only briefly, that his Italian training was all for naught, and the reader starts to wonder along with him whether, with all this bureaucratic fumbling, he will ever see battle. While the letters from this period include some accounts of his latest flight instruction, the overwhelming message is one of despair.

Finally, in October 1918, Rowe is posted to a pursuit squadron. All his training in Foggia and in France must have paid off because he is selected to fly with the 147th Pursuit Squadron, one of the most famous American units. The trouble is that, as a recruit, Rowe has to wait his turn to share a "machine." The Armistice is only a fortnight away when he gets to fly a SPAD XIII in combat. This he accomplishes by asking a squadron mate to play sick.

As in the post-war silent serials, you will have to wait to see what happens to our hero. For those interested in World War I, this book is a must. The 125 personal photographs alone are worth inspecting. Overall, Rowe's letters provide a fresh and interesting look at the experiences of the unsung, but nonetheless important, American World War I aviators.

—Karl S. Schneide is a curatorial assistant for flight materiel at the National Air and Space Museum. He has a lifelong interest in World War I aviation.



**Communion: A True Story.** By Whitley Strieber. Beech Tree Books/William Morrow, 1987. 299 pp., \$17.95 (hardbound).

French computer scientist Jacques Vallee, himself the author of several books on unidentified flying objects, once noted "that it no longer matters whether UFOs are real or not; people *behave* as if they were anyway." Vallee was referring specifically to space age psychological and social attitudes that take for granted the existence of flying saucers and extraterrestrial visitors. But if the spring book lists are any indication, his observation also applies to the behavior of a growing clique of respectable authors and publishers: 1987 may well emerge as the Year of the UFO.

First off the presses is Whitley Strieber's *Communion*, an account by a popular writer of imaginative thrillers (including *War Day* and *Nature's End*, both co-authored with James Kunetka) of his alleged abduction by aliens.

Prestigious Atlantic Monthly Press dips its toes into still-chilly waters in late May with attorney Gary Kinder's *Light Years: An Investigation into the Extraterrestrial Experiences of Eduard Meier*. Meier is a Swiss farmer with one arm and a sixth grade education who has snapped hundreds of spectacular photographs of possible UFOs and claims to be the recipient of more than 130 drop-in visits by extraterrestrials. Like the aliens in actress Shirley MacLaine's autobiographical *Out on a Limb*, Meier's visitors reportedly hail from the Pleiades. Though the case is widely regarded within the American UFO community as an elaborate hoax, Kinder sifts through a massive amount of material, including reams of transcripts and piles of metal samples supplied by Meier, in an attempt to authenticate Meier's claims.

At about the same time, Random House will publish *Intruders: The Incredible Visitations in the Copley Woods* by New York abstract artist Budd Hopkins. Hopkins, a specialist in UFO abduction cases, worked with Strieber and figures prominently in *Communion*.

Accounts of contacts with UFO occupants got off to a rather dubious start in the early 1950s, with the publication of hamburger-stand-owner George Adamski's *The Flying Saucers Have Landed*. Adamski's supposed contact, a long-haired Venusian named Orthon, expressed concern about "radiation from our nuclear tests." Adamski himself went on to become something of a celebrity, appearing on radio and television and authoring a second bestseller, *Inside the Spaceships* (activities, incidentally, that would seem to put him in

a league with Strieber). Books by other contactees followed, most repeating Adamski's original scenario. The alienauts were not only more technologically advanced than Earthlings, they were spiritually loftier. A dire future was inevitable, they prophesied, unless mankind mended its ways. As a last resort, the aliens would intervene to prevent humanity from destroying Earth.

The cast of characters has changed over the years, but the story remains remarkably unchanged—with some notable exceptions. Whereas Adamski went willingly to his meeting with Orthon, subsequent contactees claim to have been abducted. They frequently report humiliating physical examinations and lapses of memory and time. *Communion* clearly falls within the latter category.

Indeed, Strieber's case is in many ways typical of the contemporary abduction genre: the new contactee sometimes has the feeling of being constantly monitored. In fact, he or she may recall a series of abductions and examinations dating back to early childhood. Hypnosis is routinely employed to bring out "memories" of the experience.

As sincere as he is, Strieber offers precious little hard evidence that he was kidnapped at all, much less by extraterrestrials. And therein lies the major stumbling block to scientific acceptance of his and similar stories. Strieber's text is largely based on a combination of conscious memory, childhood presentiments, hypnotic testimony, and even dreams, all of which will do little to knock any skeptic from his or her comfortable perch. Ultimately, little emerges from Strieber's "extraterrestrial" communion, including his legitimate concerns for Earth's future, that could not just as easily have had its origins within a more terrestrial framework.

As a mental exercise in exobiology, however, his speculations on a hive-like species of individuals sharing a common mind is at least stimulating. Now that the spacecraft *Voyager 1* carries our home address with it beyond the solar system, it's not too soon for us to start practicing communication with extraterrestrials.

And maybe, as Strieber himself admits, the alien invasion is more mental than material anyway—simply an idea whose time has come. The contested territory, then, is not a highly populated universe, but the equally vast and crowded interior of the human mind. According to Vallee, ETs have already established a significant psychological beachhead that they show no signs of surrendering.

In the meantime, we might be wise to remember the words of another

Frenchman, the Marquis Pierre Simon Laplace, an 18th century mathematician and astronomer, who wrote, "The weight of the evidence must be in proportion to the strangeness of the fact." Though the notion that we may not represent the pinnacle of evolution even within our own galaxy seems less radical than it once did, it's still going to take a lead balloon of a UFO to convince most of us that the moment of contact is finally at hand.

—Dennis Stacy is a San Antonio writer and editor of the monthly MUFON (Mutual UFO Network) Journal.

**Halley's Comet Revealed.** A slide set by John C. Brandt. Produced and distributed by The Astronomical Society of the Pacific, 1986. 19-pp. booklet and 17 slides, \$16.50. Available by order from ASP, Halley Slides Dept., 1290 24th Ave., San Francisco, CA 94122.

For anyone who spent too many chilly hours searching the skies for Halley's comet, only to be rewarded by a glimpse of a dim, blurry, and altogether uninspiring splotch of light, this slide set will serve as a reminder of what all the fuss was about. The slides do indeed reveal Halley's Comet in all its glory, both as a beautiful spectacle and as a fascinating scientific phenomenon.

In aesthetic terms, the final slide, "Comet Halley and Saquaro Cacti," is surely one of the most striking comet images around. Another slide, composed of three photographs taken on three consecutive nights in January 1986, is more difficult to decipher but, from a scientific point of view, more intriguing: it shows a "disconnection event," in which the comet's plasma tail separates from the comet's head and a new tail quickly grows in its place.

The booklet that accompanies the slides is written by the chief of the laboratory for astronomy and solar physics at NASA's Goddard Space Flight Center, John C. Brandt. His text includes background information on the composition and physical properties of comets, an outline of spacecraft missions to the comet and their results, and captions for each slide. The booklet is informative and concise—perhaps too concise at times, but fortunately it concludes with a helpful list of further readings.

Taken together, the slides and booklet can serve as a fitting memento of Halley's most recent apparition—or a preview for those hoping to get a better look next time.

—Katie Janssen



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## Credits

**Fire Bombers.** Michael Tennesen is a freelance writer who lives in Lomita, California. His articles have appeared in *National Wildlife*, *Los Angeles Magazine*, and *Travel and Leisure*.

Further information: "Brimstone Bombers" by George C. Larson, *Flying*, vol. 96, no. 1, January 1975.

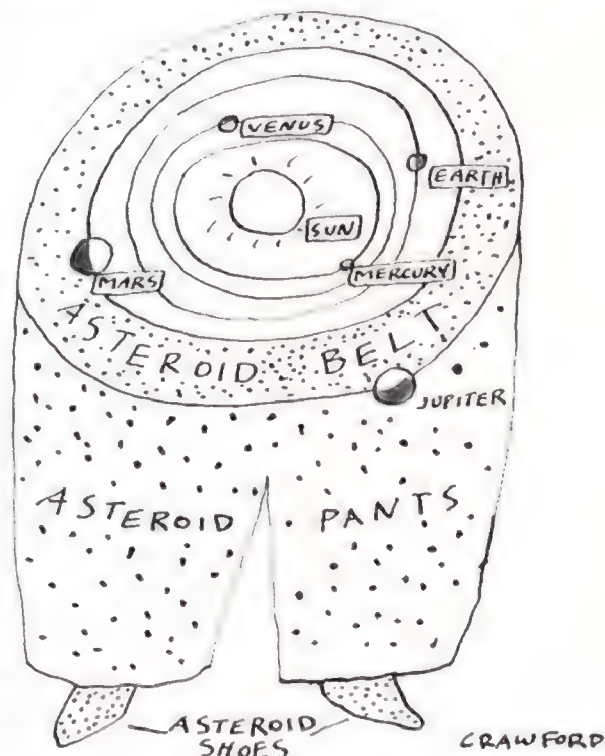
**Eyes on the Sky.** James E. Oberg is a self-described "Soviet space sleuth" and the author of many articles and books about space, including *Red Star in Orbit* (Random House, New York, 1981).

Further information: *Artificial Space Debris* by Nicholas L. Johnson and Darren S. McKnight (Orbit Book Company, Malabar, FL, 1987).

*The Encyclopedia of U.S. Spacecraft* by Bill Yenne (Exeter Books, New York, 1985).

**Trial by Flying.** F. Lee Bailey is a trial lawyer, author, and public speaker.

**Smokin' Steve Poleskie.** Stephan Wilkinson once purchased an Aston Martin from artist Larry Rivers, but he has no such aspirations to obtain Steve Poleskie's Pitts biplane. His last article for *Air & Space/Smithsonian* was "The Search for



L'Oiseau Blanc," in the February/March 1987 issue.

Further information: "Sky Dances of the Maumee" by Steve Poleskie, *lightworks*, no. 17 (P.O. Box 1202, Birmingham, MI 48012).

**Dash 80.** R.G. Thompson was raised in Seattle under a canopy of Boeing airplanes. A journalist since 1952, he has written some 30 books, most about wine and travel. "Dash 80" is his first article about airplanes.

Further information: *Boeing 707* by Martin Caiden (Ballantine Books, New York, 1959).

**The Big Picture.** Steven L. Thompson is a former executive editor of the Aircraft Owners and Pilots Association magazine, *Pilot*, and the author of a series of spy novels. His article "The Great American Pilot Shortage" appeared in last year's October/November issue of *Air & Space/Smithsonian*.

Further information: "Virtual Cockpit's Panoramic Displays Afford Advanced Mission Capabilities," *Aviation Week and Space Technology*, vol. 122, no. 2, January 14, 1985.

**The Curator of Cosmic Dust.** Alcestis R. Oberg's most recent book is *Pioneering Space: Living on the Next Frontier* (McGraw-Hill, New York, 1986), written with her husband, James. She would like to someday write a book about cooking in space. Oberg lives in Dickinson, Texas.

Further information: *Cosmic Dust* by James Anthony Michael McDonnell (Wiley, New York, 1978).

**Rendezvous in Near Space.** F. Gerald Phillips is a retired lieutenant colonel of the U.S. Air Force and an aviation historian and aerospace writer. He has been an active pilot for over 60 years.

**The Farm.** Edwards Park was one of the founding editors of *Smithsonian* magazine. "Featherwaste," his last article for *Air & Space/Smithsonian*, appeared in the August/September 1986 issue.

**The Happy Landing.** Elaine de Man is a freelance writer whose work has appeared in *Omni* and *Technology Review*. She lives in Alameda, California. She wrote "Orbis Helps the World to See" in the December 1986/January 1987 issue of *Air & Space/Smithsonian*.

**Special Insert: The Satellite Sky.** Saunders Kramer has been tracking satellite launches since 1957's Sputnik.

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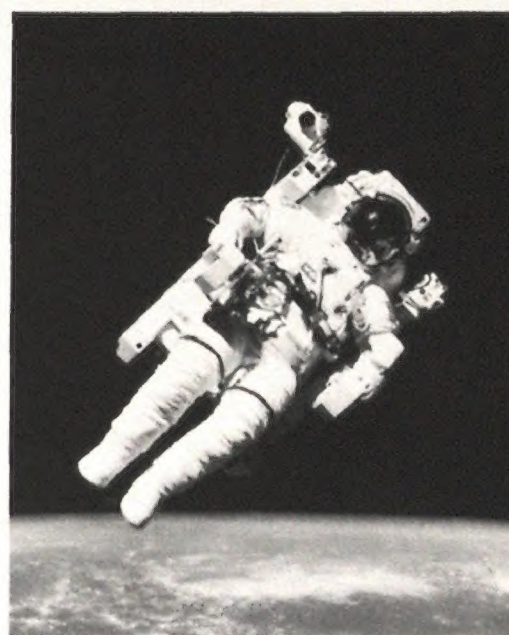
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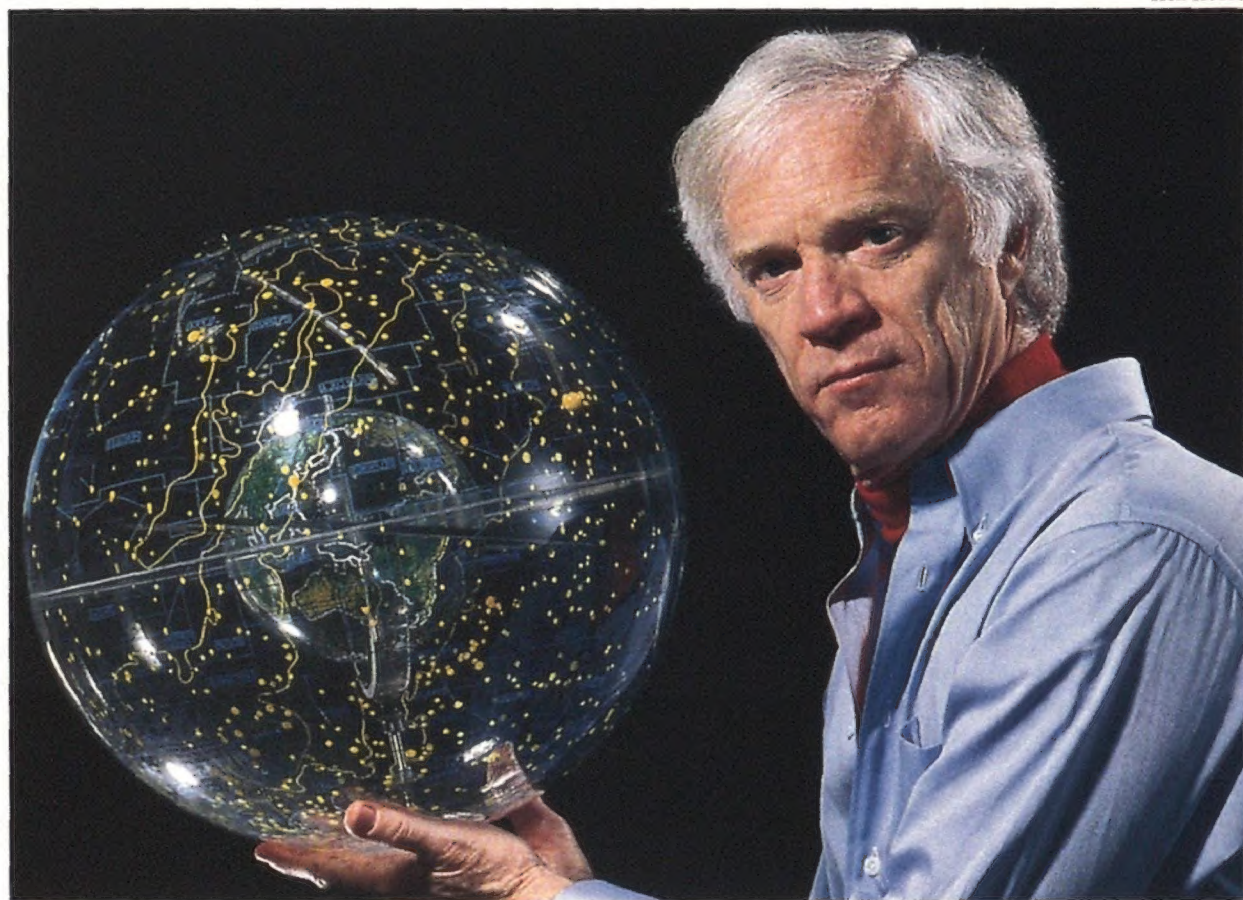
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**Backstage with the Thunderbirds**—Six Air Force pilots share the airshow spotlight, but the stars are the first to tell you it's the support team of 125 that gets this show on the road.

**Still Earthbound After All These Years**—When its flight is postponed, a satellite can't saunter over to the airport bar to while away the hours. The Hubble Space Telescope was to have been launched by shuttle last fall. Now, a 1988 launch date is looking optimistic.

Ken Kobre



Robert Caputo



**Over Africa**—With a *whoosh* of hot air and a dash of romance, Alan Root takes tourists for a ride. Aboard his aerial observation posts, passengers get a lofty perspective on African wildlife.

**Swift's Science**—In the course of his travels, Gulliver came upon a land in which scientists had discovered and tracked two moons of Mars. The strange thing is, Swift wrote this story 100 years before astronomer Asaph Hall discovered the real Deimos and Phobos.

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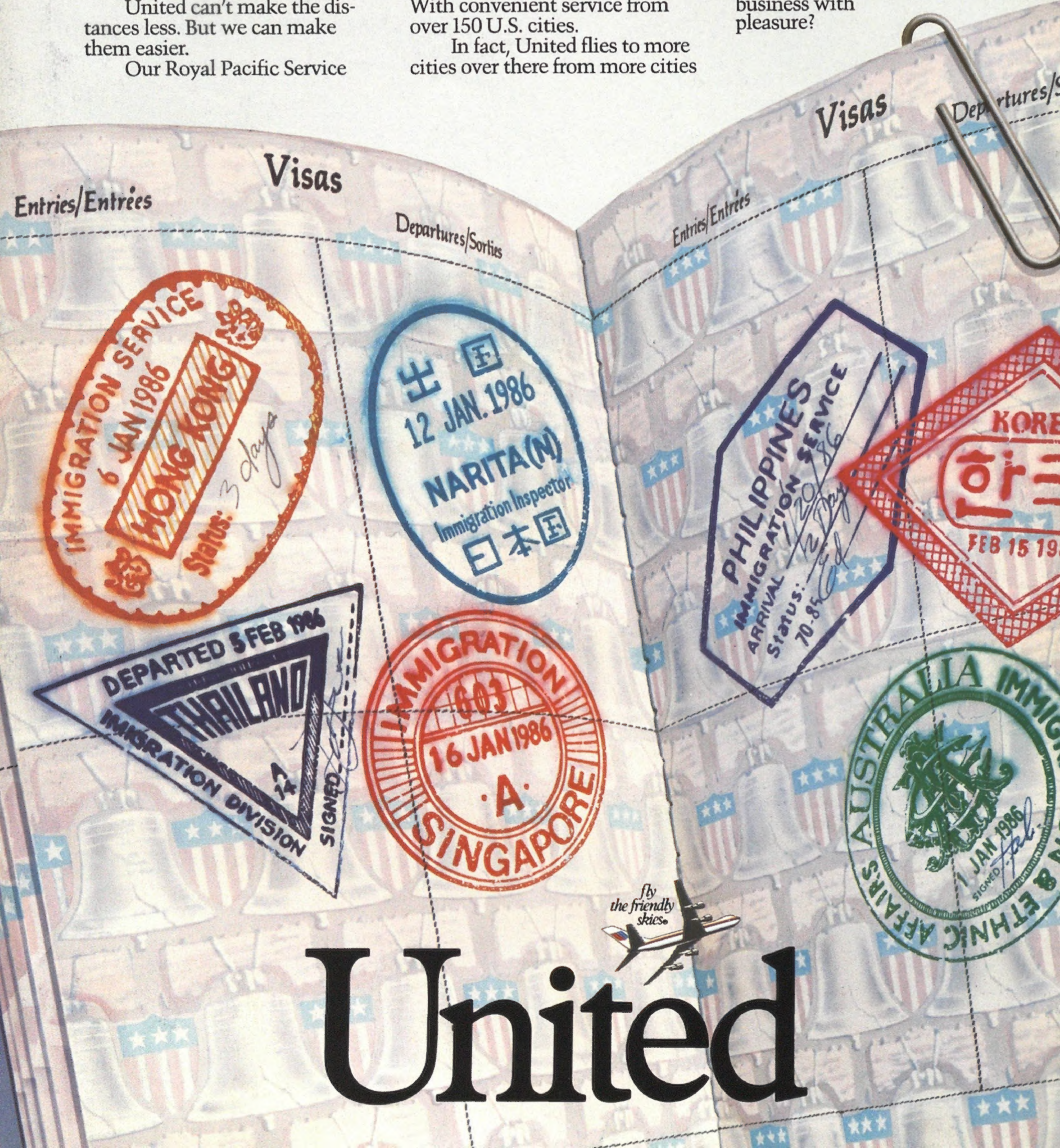
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